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SCIENCE IN THE HIGH SCHOOLS, AN INVESTIGATION.[1]

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How is science now being taught in high schools? What has been the effect of the demand for practical and vocational courses? What adjustments in the courses in pure science have been made to satisfy this demand? The demand comes under various guises, such as "practical courses," "vocational courses" and "applied courses." Within the last two or three years great pressure has been brought to bear upon teachers of the pure sciences to modify these courses and make them more "practical," as it is usually put. How this pressure has been met, is the question which I have set myself to answer in so far as the scope and means of such an investigation as this can determine.

It seemed best to begin by studying the situation in Chicago, since I am well acquainted with the history of science teaching in this city from the time of the inauguration of modern laboratory methods, and since also the evolution of science teaching in Chicago is undoubtedly similar to its evolution elsewhere, except that it is slower because of the larger bodies of people to move.

There has been a slow evolution in methods of teaching the various sciences from the very beginning of the establishment of the laboratory. The present agitation has only served to accelerate somewhat a movement already in progress. At first there was insistence upon strict scientific methods—such as the inductive process of observation and inference. A text-book open in the laboratory was strictly forbidden. The study of types with the emphasis on morphology was insisted upon. The order of study was always evolutionary. Even the laboratory tables were copied from the style found in college laboratories. In fact, the entire course was modeled on the college course—simply a slightly modified edition of the college course. The tendency has been away from this hand-me-down college

[1]From the report of a committee appointed by the state Academy of Science of Illinois to "Investigate the Relations of the Pure and Applied Sciences in High Schools" transactions Vol. V, 1912.

work toward something specifically suited for high school needs, —a high school course in science suited to the experience, ability and needs of the high school pupils. I think I can illustrate just what this progress has been best by taking one of the sciences and comparing a former course used in Chicago with one recently adopted. For this I am going to take botany, since in most or all of the other sciences, whether or not the experiences of the home and daily life are utilized, is a matter of laboratory practice in the application of the topics of study, while in botany the topics themselves give a hint as to the method used. In physics, for example, the topics electricity, heat, light, etc., will appear in all courses, no matter what the treatment, and only a study of the methods in use in applying the topics will show what progress has been made.

For the purpose of this inquiry it will be sufficient to compare two courses of study for botany—one dated June, 1908, and in official use since that time, the other recently adopted for future guidance.

BOTANY.
LABORATORY AND FIELD COURSE. 1b.
(In effect Sept., 1912.)

Topics.	Suggested Subtopics.
Fall flowers	Principal types of common wild and garden flowers, especially the compositæ. Insect pollination.
Leaves	Work of leaves. Light relation of leaves. Identification of trees by their leaves.
Weeds	Types of weeds and their characteristics. The struggle for possession. Collection of common weeds.
Seeds and fruits	Types of seeds and fruits; methods of distribution. Collecting seeds; planting tree seeds.
Preparation of plants for winter	Trees, perennials, biennials and annuals considered in this relation. Bulb culture.
Forestry	Identification of trees in winter conditions. Planting and caring for trees; forestry. Enemies of trees.
Algæ	The cell; plasmolysis. Types of algæ showing development of plant body. Types of reproduction; establishing home aquaria.
Fungi	Life history of a fungus. Types of fungi from an economic standpoint. Bacteria.
Liverwort, moss, fern, pine	Evolution of the plant body. Spore reproduction; the seed.
	1a.
Seeds and seedlings	Germination; the seedling. Seed testing; food storage; uses to man. Respiration; response to stimuli.
Roots	Types, modifications. Food storage; uses of roots by man. Functions of roots; soils and fertilizers.
Stems	Types, structure and modification. Work of stems; uses to man. Woods; identification and collection.
Leaves	Structure, modifications. Work of leaves; economic uses.
Gardening, window and outdoor	Planting rules, planning garden and homeyard. Garden accessories, hot beds, cold frames, etc. Types of garden plants; propagation of plants, cuttings, grafts, offsets, etc.
The flower	Structure and function by means of a typical flower.
Local flora	Types of flowers, flower families. Wild flower collection, flower calendar. Uses of keys; how to make an herbarium.

COURSE IN BOTANY.

Condensed from official bulletin.
(In effect Sept., 1908.)

1. A laboratory course, following the authorized manual, including first-hand notes and drawings.

No. lab. *periods.	Branch or Topic.	Type—for careful study.	Comparative study.	Experiments and observations in physiology.
8	Algæ.	Pleurococcus. Spirogyra.	Vaucheria. Fucus.	Osmosis. Photosynthesis. Response of cell contents to alcohol, iodine and salt solution. Necessity of soil salts.
8	Fungi.	Yeast. Mucor.	Microsphæra. Mushroom.	Conditions for growth. Need of food.
1	Lichens.	Lichen.		
7	Bryophytes.	Marchantia. A Moss. (Complete life history.)		Power of revival after drying.
12	Pteridophytes.	Fern (both generations).	Equisetum. Lycopod.	Grow fern spores.
4 8 12	Gymnosperms. Monocotyledons. Dicotyledons.	Pine. Lily. Mustard.	Some other monocotyledon A crowfoot; a rose; a violet; a legume; a figwort. A composite.	Osmosis in seeds; in root hairs; in root (carrot exp.). Photosynthesis, need of light; need of carbon-dioxide; product. Circulation.
10	Seeds and seedlings.	Beans; Squash; Corn.	Five other seeds collected by the pupil.	Seed germination, the conditions as to water, heat air, light and external plant food. Place of growth in seedling, root and stem. Respiration.
5	Roots.	Oat; Bean; Carrot.	Anacharis root. Clover roots.	Response to stimulus. Plant storage. Root pressure.
8	Stems.	Cottonwood. Ash.	Grape; wild cucumber; potato; onion; trillium.	Water content, soil, green wood, herbs, fruits.
12	Leaves.	Geranium.	Solomon's seal; clover; ash.	Transpiration, rate and amount. Wilting and restoration. Use of protective covering.

* Single periods—about 45 min.—3 or 4 periods per week.

A comparative study of these two outlines shows that in the earlier one the year's work was divided into two parts corresponding to the semesters, one occupied with a survey of the plant kingdom taking up the groups in evolutionary order, the other, usually given in the second semester, dealing with the seed plants and outlined in structural order. Theoretically this looks like an ideal plan, and it appealed to college men who write text books in botany for us and to teachers of botany fresh from the university, as the only course to give. But we who are in the business of teaching botany in high schools had difficulties in applying it. Our pupils were not interested, little enthusiasm could be aroused, many pupils failed—in fact, only the brightest pupils got anything out of the first semester's work. The second semester's work was needed to restore interest lost in the first half year's work, and even that dealt with structure to such an extent that the interesting spots in the course were in danger of being lost sight of. The work on the local flora in the spring was the only thing that saved our classes in botany from extinction. We turned out few botanists.

As soon as the average teacher realized what was happening, he began to inject into the course various features, mostly in the line of field and home studies, to add interest and appeal to the experience of the pupil. The most popular of these were studies of fall flowers, leaves, trees, woods, and various studies of the commercial uses of plants and plant parts.

Turning now to our recently adopted course, it is easy to see how this has finally worked out. It will be noted at once that the studies of plant groups occupy only about half of a semester, instead of an entire semester. Evidently, detailed studies of structure must be omitted in using this course, for there will not be time. The title itself is quite illuminating, indicating that the laboratory is not the only place to study botany. It is interesting to note various topics not found in the old course, all of which appeal to the human interest of the pupil, such as fall flowers, preparation of plants for winter, forestry, gardening, local flora, etc.

Another very interesting and significant feature is the comparative flexibility of the two courses. In the old course the amount of time to be given to each subject is stated in hours. No such statements are to be found in the new course. The types in the old course are all stated positively, while in the new course the heading reads "suggested subtopics." Again, in the statement

accompanying the new course, the teacher is given entire liberty with respect to the order in which the topics shall be taken up. The first course is arbitrary and inelastic. The new course is flexible and easily adjusted to any teacher's special needs.

The trend has been away from a strictly scientific development of botany which did not recognize the pupil and his interests to a flexible course, where the purely scientific development of the subject has been subordinated to the development of the pupil's interest in botany. The scientific aspects are not lost by any means, but they are not the sole thing now.

I have given a good deal of time to the study of the development of botanical teaching in Chicago, because it seems to be typical of the trend in all the pure sciences. It will therefore not be necessary to give much time to a consideration of the other sciences. Zoölogy has experienced like changes in method indicated by the use of the insects as an introductory study and by the dropping of the echinoderms from the course. This last was not done without a struggle, for the impulse to take up the groups one after another, omitting none, is very strongly rooted in the minds of zoölogy teachers.

In physics there is consistent effort to make application of the laws and principles of the science to problems of everyday life. In chemistry, analysis of food adulterants and other articles used in the home give the needed relation of the subject to the pupil's experience.

It would not do to assume that conditions in Chicago necessarily resemble those in other places. I, therefore, undertook an investigation to ascertain how the pure sciences are being taught in various other parts of the country. Manifestly, this could not be done by examination of courses of study, and so I prepared a brief questionaire which I sent to representative schools in Illinois and other States of the middle West, and a few to the extreme West. The returns were fairly satisfactory, considering that it required the combined reports of teachers of four departments.

For botany and zoölogy the following questions were asked: 1. State in order as given by you the topics and groups of plants (or animals) taken up during the year and the time allowed for each. 2. Upon what do you place most emphasis? 3. What, and how much, outdoor work do you do with your classes For physics and chemistry there were two questions: 1. State in order as given by you the topics taken up during the year. 2. Do you do

OUTLINES OF COURSES OF STUDY. BOTANY.

Place.	Time sem.	Course.	Emphasis placed upon.	Field work.
Menominee, Wis.	2	Leaves, flowers, fruits, seeds, stems, 8 weeks; corn plant, oat plant, potato plant, 3; bacteria, 2; algæ and fungi, 6, liverworts, mosses, ferns, 3; spring flowers, about 12 weeks.	Corn, bacteria, fungi, spring flowers.	About 4 trips.
Minneapolis, Minn.	2	As in Coulter's text book of botany. Higher plants, 6½ months; fungi and bacteria, 1 month; algæ, mosses, liverworts, ferns, 6 weeks.	Trees, weeds, economic factors.	One lesson each week during spring and fall.
Detroit, Mich.	2	First semester, life history of angiosperm, plant—seeds, seedlings, roots, stems, leaves, flowers, fruits, a few common families. Second semester,—life history of typical forms of algæ, fungi, moss, ferns. Preparation of herbarium. Study of stem structure and woods.	Development of power to observe, study and correlate facts of plant life, relation of plants to surroundings.	Study habits of plants—identification of native and shade trees.
Aurora, Neb.	1	Seeds, roots, stems, leaves, fruit, flower. 2. Physiology of the above. 3. A brief view of ecology. 4. Economic importance of plants. 5. A brief study of cryptogams.	The structure and physiology of common flowering plants found in our neighborhood.	One excursion.
Quincy, Ill.	2	1. Plant relations. An introduction to forest trees, collecting, drawing, and mounting woods, foliage, leaves and seeds. 2. Plant structure. Collecting, drawing and mounting 25 flowering plants. Drawings showing development of leaves of a particular plant from bud to maturity. A further study of forest trees.	Ecology.	One period each week (2 hrs.).
Saginaw, Mich.	2	Leaves 10 weeks, stems 6, roots 4, seeds 4, germination 2, the cell 1, algæ 2, fungi 2, mosses 2, ferns 2, flowers and fruits 5.	Structure and functions, classification trees, shrubs, cultivated plants, alternation of generations.	Fall and spring, 20 periods in yards and parks.
Ft. Wayne, Ind.	2	1. Seed plants,—morphology, physiology and ecology of seeds, leaves, bud, stem, flower, fruit. Plant societies, classification, economic value of main groups. 2. Life histories,—algæ, fungi, mosses, ferns, shrub mosses, gymnosperms, angiosperms.	Morphology, evolution of plants, economic value.	Assigned work, pupils gather laboratory materials.

Ottumwa, Iowa.		1. Seed plants, leaves, 10 weeks (4 weeks to identification of trees by means of leaves), roots 2, stems 3, seeds 3. 2. Algæ, fungi, liverworts, mosses, ferns, flowers; identification of flowering plants.	Recognition of common trees, life process, food tests, etc.	Study trees. Pupils collect twigs of 50 trees. Ecological studies made. Assigned work.
Kansas City, Mo.	2	Flowering plants 4 weeks, algæ 4, fungi 6, bryophytes 1, pteridophytes 1, spermatophytes 8, plant processes 4, plants of economic importance, products, etc., 12 weeks, e. g., bacteria and disease, medicinal plants, trees and their woods and their uses, propagation of plants (have a green house).	Evolution and economic importance.	Several trips during fall and spring. Assigned individual work.
Crookston, Minn.	2	Anatomy and physiology of plants 13 weeks, ecology 8, cryptogams with emphasis on parasitic fungi 7, classification and preparation of herbarium 4, reviews 4 weeks.	Ecology, economic importance, work of plants, recognition of common plants.	Excursions for identification of weeds and other plants, collecting trips.
Monmouth, Ill.	2	Leaves, stems, roots—germination of seeds, 35 periods. The groups algæ to gymnosperms 29, angiosperms (general) 9, flowers and insects, seed dispersed 5, monocotyls 5, dicotyls 12, plant breeding, forestry, plant associations 4, collect and mount 20 wild flowers, analyze 15.	Structure and adaptation in field and laboratory studies, economic importance.	Group work under teacher's direction. Collecting specimens.
Lansing, Mich.	1	Entire time given to flowering plants, 3 weeks on analysis flowering plants. Aim to make nature lovers of pupils, not scientists.	Plant as an individual in a certain relation to its environment.	Study of a selected tree throughout season. Collecting specimens. Volunteer work.
Indianapolis, Ind. Shortridge H. S.	2	Identification of trees, forestry studies as field work. Algæ 6 weeks, fungi 5, liverworts, mosses, ferns 6, pine 1, seeds and germination 4, roots 2, stems, 3, buds 2, leaves 2, flowers 5 weeks. Much practical work in gardening, forestry, fruit culture, flower calendar, etc.	Economic applications. Acquaintance with common plants.	Five required trips, others optional. Collecting tree leaves, 30 required, 30 to 95 collected, making flower calendar of 40 to 260 plants.
Ottawa, Ill. Township H. S.	2	Thallopytes about half semester, bryophytes spring and pteroidophyter rest of semester, Spermatophyter semester. Some ecological work is given and lasts 8 weeks, given to determination of species of plants 3 hours per week.	Evolution of plant life and physiology of plants.	Ecological work and identification of plants.
Kewanee, Ill.	1	Four groups, mophological study 7 weeks, physiology of angiosperm types 6 weeks, ecolory of rerion and some agricultural problems 5 weeks.	Physiology and ecology.	Very little. Classes too large.

Place.	Time sem.	Course.	Emphasis placed upon.	Field work.
Cedar Rapids, Iowa.	2	1. Field and laboratory study of weeds, seed dispersal, identification of 30 common weeds. Relation of flowers and fruits. Germination studies. Life relations, structure, physiology and ecology of roots, stems, leaves. Soil studies—Plant growing room provides specimens at all times. 2. Winter condition of buds, field study of trees. Plant groups. Plant families of locality. Pollination studies, plant breeding.	That phase of the work with which the pupils are most vitally concerned in their out-of-school life. For example, plant propagation, bulbs, grafting, condition of fruit buds in spring, etc.	Eight to ten excursions to fields during class hours. Much assigned individual work on special topics during entire year, often requiring daily outdoor studies.
Sycamore, Ill.	1	Seeds and their foods 5 weeks, roots 2, stems 4, leaves and light relations 3, algæ 1, mosses and ferns 2, weeds and struggle for existence 1, plant breeding 1.	The plant as a whole and as a part of the organic world.	Special topics assigned. Four excursions to study tree forms, light relations and plant distribution.
Paris, Ill.	1	Angiosperms 11 weeks, pteridophytes 3, fungi and algæ 2, gymnosperms 2.	Conditions of economic importance as soil, seeds, parasites. struggle for existence.	Individual field work—classes too large for class excursions.
Pontiac, Ill.	1	Atkinson Text—General plant anatomy, stem, leaf, seed, etc., 2 months. Work of plants, economic value, 2 months. Systematic botany, 1 month.	Work of plants.	Much of the last half month.
Waterloo, Iowa.	1	Stems and buds 3½ weeks, roots 1, seeds and germination 2½ weeks, leaves 2, cryptogams 2, flowers and classification 4, fruits 1, leaves 1.	Physiology and ecology.	One or two trips to study plant associations and adaptions.
Aurora, Ill. East Side H. S.	1	Tree study 5 weeks, leaves, stems, roots, seeds and seedlings, comprising their anatomy and physiology, 15 weeks. Second semester—Bacteria 2, algæ 3, fungi 4, lichens 1, mosses and liverworts 2, ferns 2, flowers 2, weeds 4 weeks.	Economic importance.	None except tree and flower study, which is more nature study than pure botany.
Macomb, Ill.	1	Seeds and seedlings 2 weeks, roots, stem leaves, flowers, fruits, including functions and reactions to stimuli, 10, algæ 1, fungi 1, bryophytes 1, pteridophytes 1, gymnosperms 1, herbarium and classification 2 weeks.	Physiology of the higher plants.	None.
Waukegan, Ill.	2	Structure and functions of seed plants (except flowers), 8 weeks; evolution of plant kingdom, 12 weeks; ecology and economic value fruits and seeds, 4 weeks; local flora, classification and herbarium making, 12 weeks.	Fitness of plants to live in their environment.	Materials gathered. Most work in spring.

Streator, Ill.	1	Activities, structures and relations of leaves 4 weeks, roots 1, stems 3, flowers and fruits 2, seeds and germination 2, dependent plants and bacteria 2, evolution and plant breeding 2, principal families of higher plants 4.	Plant as a living working organism. Identification of common plants. Economic relations.	Ten to fifteen periods.
Rockford, Ill.		Fall flowers and weeds, 4 weeks; light relations of leaves, leaves and fruits of about 45 trees, shrubs and vines, 5; microscopic structure of leaves, algæ physiology of green plants, 7; bacteria and other fungi, 3; winter condition of trees, stems, structure, 5; germination, soils, seed testing, foods in plants, 4; mosses, ferns, conifers, 3; spring flowers, plant families, cross pollination, plant breeding, plant societies, 9.	Recognition of common plants. Physiology and ecology of plants. Materials used in laboratory. Make course in botany foundation for agriculture as well as for biological science.	Several during fall and winter for materials for class-work, flower calendar, and leaf and fruit collections. Weekly trips in spring.

OUTLINES OF COURSES IN ZOOLOGY.

Place	Sem.	Course.	Emphasis placed upon.	Field work.
Jacksonville, Ill.	2	Insects, typical invertebrates, vertebrates, 12 weeks each. Botany and zoology taught alternate years. General science first year.	Animals harmful to crops, orchards and gardens. Animals useful to man. Birds.	All materials studied in laboratory collected in field trips. Birds studied.
Detroit, Mich.	2	Insects,—collect and identify 6 or 7 orders; life histories and economic value of common forms, 6 to 8 weeks; protozoa, annelida, mollusca, crustacea rest of semester. Vertebrates,—lower chordates, pisces, amphibia, reptilia, aves, mammalia, 4 to 5 weeks each on birds and frogs.	1. Same as in botany. Applying knowledge gained in study to everyday life.	So far as possible study habits and hibernations of all forms, also relations of insects and birds to plant life. Identify 40-50 birds.
Aurora, Neb.	1	1. Typical specimens of each of the group. 2. Identification of laboratory specimens. 3. Economic importance of animals.	1. Identification of laboratory specimens. 2. Economic importance.	None.
Quincy, Ill.	2	1. Arthropods to protozoa. 2. Fishes to man.	Life relations. That zoology is a subject that pertains to "here and now."	Seeing "our little brothers" in their respective homes. At least one period each week during good weather.
Ottumwa, Iowa.	2	Insects, 3 months, spider, crayfish, earthworm, nereis, clam, starfish, hydra, protozoa, fish, frog, bird in order.	Morphology. Economic zoology. Collect 50 insects.	At least once a week for bird study in spring. Insect work in fall.
Sycamore, Ill.	1	Insects 3 months, protozoa and hydra 3 weeks, crayfish 2, worms 2, frogs 1, fish 1, birds 2, mammals 1, summary and evolution 1.	Relation to environment and man.	Two or three class trips. Individual collecting trips.

Place.	Sem.	Course.	Emphasis placed upon.	Field work.
Paris, Ill.	1	Arthropods 6 weeks, annelids 2, echinoderms 1, mollusca 2, glimpses of lowest forms, chordates 6, survey of evolution 1 week.	Habitat and distribution. Relation to environment. Economic importance.	Student must collect specimens of forms used in laboratory.
Pontiac, Ill.	1	Insects 6 weeks, other phyla 8, ecology of animals 4 weeks.		None. Pupils required to secure most of laboratory material.
Kansas City, Mo.	2	Insects 6 weeks, protozoa 4, coelenterates 3, worms 3, mollusks 2, arthropods 4, echinoderms 1, chordates 12, insects 4.	Evolution and economic importance.	Students collect most of the materials used in laboratory; 3 or 4 trips in fall and spring.
Danville, Ill.	2	Insects 6 weeks, the cell, mollusca to protozoa, vertebrates. Special study of birds.	Well done note book work, careful dissection of a few types, environmental influences.	Collect 50 insects, and report on their mode of life.
Lansing, Mich.	1	Each of chief groups taken up. Two weeks to general principles.	Insects and mammals, economic value.	Collections of insects; outlines for field study by pupils; a few voluntary trips.
Aurora, Ill. (West Side)	2	Insects 2 months, other arthropods 2, echinoderms, coelenterates, protozoa 1, vertebrates rest of year.	Economic importance; habitat and adaptations; enemies and allies.	Collecting material by class for use in laboratory.
Indianapolis, Ind. Shortridge H. S.	2	Time, 5 double periods per week, 10 months. Insects 6 weeks, cell and protozoa 3, sponges and coelenterates 2, worms 3, crustaceæ 2, fishes 4, amphibia 3, reptiles 1, birds 5, mammals 5.	Principles of biology. Growth development, parasitism, adaptations, economic importance, conservation of natural resources.	About 10 field trips, much individual work, bird records by all and an insect collection. Each pupil takes one field on which he reports.
Ottawa, Ill.	2	Insects 6 weeks, other arthropods 2, mollusks 2, worms 4, lower groups 6, vertebrates 18 weeks.	Insects and vertebrates, structure and economic relations.	About 1 hour a week for eight weeks.
Kewanee, Ill.	1	Insects, mollusca, porifera, protozoa receive most time, others briefly.	Economic value—animal and its environment.	One or two collecting trips.
Cedar Rapids, Iowa.	2	Insects 6-7 weeks. Follow this protozoa to vertebrates.	Environmental conditions, economic value.	Field work on insects and birds. Six to eight field trips.
Denver, Colo.	2	Beneficial and injurious insects 6 weeks. Brief survey of each phylum. Special attention to local fauna, animal characteristics, struggle for existence, life cycle, mimicry, development, communal life, etc.	Study of animals, not books. Fresh material.	One class makes field trips each week—large amount of living brought in and kept in laboratory.
Waterloo, Iowa.	1	Insects 8 weeks, crustaceæ 2, worms ½, mollusks 1, echinoderms and coelenterates 1, amphibia and fishes 2, and birds 1½, and mammals 2.	Economic importance, adaptation of structure to function.	One field trip in fall.

"PRACTICAL" WORK IN PHYSICS AND CHEMISTRY.

Place.	Physics.	Chemistry.
Menominee, Wis.	Pupils work out special topics,—city water works, sewing machine, automobile, steam engine, gas engine, fireless cooker, etc.	Girls study food chemistry, boys cement, bricks, iron, soil, etc.
Ottumwa, Iowa.	Practical application of everything taught emphasized. Practical problems given. Visits to power plants, etc.	Practical exercises—acid in vinegar, chemical tests of cloth fibers, baking powders, etc.
Jacksonville, Ill.	Emphasize industrial side by visiting different plants relating to our subject.	Use food tests, baking powders, fermentation, fertilizers, fire extinguishers, photography.
Minneapolis, Minn. North H. S.	Emphasize practical and everyday side of each subject as much as possible.	Experiments in miniature of commercial manufacture of certain chemicals. Test for purity of water, ores, making mirrors, bleaching, dyeing, photography, ice manufacture, etc.
Detroit, Mich.	Use laboratory experiments which have a practical bearing.	Use many experiments having practical application, as fermentation. Tests of food, carbon compounds, distillation of coal and its gases, soda manufacture, also ammonia and acids. Attempt to bring out practical bearing.
Ft. Wayne, Ind.	All laws of physics are illustrated by practical examples.	Very little. Kept busy trying to give a fair understanding of chemical laws and the necessary elementary facts.
Saginaw, Mich.	In laboratory we do not. The classes are shown the practical applications of the subject whenever possible.	Not so as to interfere with the scientific development of the subject. However, we use illustrative material drawn from the experience of the pupil whenever possible. Expect to start a special course for girls.
Moline, Ill.	All illustrations are made to apply directly to the commonest things of life. All experiments are made practical so far as possible.	Only enough theoretical work is taken up to make our work an orderly arrangement. No practical application neglected.
Elgin, Ill.	Determination of brake horsepower of a motor; heat content of city gas; heating and ventilation of our school building; rate of consumption of gas by gas stove; cost of gas and electric lights; study of gas engines.	Testing of water for impurities, dyeing, bleaching, fermentation, preservatives, testing foods for nutrients.
San Francisco, Cal. Mission H. S.	Experiments mostly qualitative to inductively present principles, not discover them. Practical applications to everyday phenomena we consider very important.	Our practical work bears on the chemistry of everyday life and home. We aim to let this take the place of the usual methods with the metals.

Place.	Physics.	Chemistry.
Rockford, Ill.	We try to see the practical application in every topic.	Test milk for fats, sugar, water, skimming and dirt. Analyze such things as sausage, pickles, coal, soil, fertilizer, stock feed, paint, baking powder, cocoa, extracts, whisky, butter, ice cream, blueing, etc. Our aim is to teach practical chemistry.
Kansas City, Mo.	As much as possible, especially in mechanic electricity and heat.	A very considerable amount,—soaps, hard water, baking powder, soda biscuit, water classification—bleaching, photography, etc.
Indianapolis, Ind. Shortridge H. S.	The work is made more vital and practical by introduction of interesting experiments, bearing directly upon the pupil's experience in daily life. (List follows; too long for this table.)	We attempt to train pupils to think and apply while dealing with the facts and theories of chemistry. (Details of this course cannot be given in this table.)
Denver, Colo.	At least half the work has practical bearing; the aim always is to make use of the past experience of the pupil, but this is difficult in mixed classes of boys and girls on account of the great difference in the experience of the boys and girls.	The work in qualitative analysis is certainly practical and in addition there are occasional visits to the smelters, chemical works, gas works, etc. Then there are examinations of milk, baking powder, water, etc.

any so-called "practical work" with your classes? If so, what?

A tabular resumé of the reports on these courses of study has been prepared and is appended to this paper. While the number of reports is not great, the schools included in the report represent a wide variety and are representative schools, so that it is probably safe to assume that their courses represent the prevailing tendencies. Wide variations are shown, especially in botany, but on the whole certain things stand out clearly, marking what we may call the attempt to relate the teaching of the sciences to the experience of the pupil.

In botany, as has been indicated, there is wide divergence, but it can readily be seen that the tendency is away from the evolutionary type method. It is also quite evident that there is as yet no settled conviction as to what should take its place. In zoölogy the insects are universally chosen for beginning the work and receive the greater share of the time. There is not much indication that the mammals are receiving a fair share of attention. If economic importance and nearness to everyday experience are to be controlling motives, then one would expect to see more time given to studies of mammals. The reports show on the whole considerably greater uniformity of practice in zoölogy than with botany.

The reports upon physics and chemistry did not give much of value on the first question so far as concerns this paper, and no tabulation of this portion has been made. The reports on the second question show almost unanimous agreement in giving the experiments a practical bearing and, in the case of chemistry, in introducing many experiments with substances used in the home. Questions were sent out for physiography, but the reports did not seem to have much bearing on the question under discussion and have not been tabulated. It is fair to say for those making reports that it was found necessary to condense the reports as much as possible for use in the tables. Some of the reports were quite extensive and deserving of publication in their complete form if space had permitted.

Considering the reports as a whole, it will be seen that there is a decided tendency toward emphasizing the aspects of each subject that come within the experience of the pupils in everyday life. In some cases it seems to have been carried to excess, notably with tree studies in some courses in botany, and possibly in some of the courses in chemistry. The important principles of each subject should never be lost sight of, no matter what

course is given, and I judge that there is danger of this in some cases. The movement, however, seems to be a healthy one on the whole and making for the good of science insofar as it appeals to a greater interest on the part of pupils and their parents. That it is a progressive movement, in which some schools have made much greater progress than others, is also evident, and what we should expect and wish for.

THE COUNTRY SCHOOL-TEACHER AS A PUBLIC-HEALTH EDUCATOR.

The country school-teacher should be a public-health educator, according to Dr. Charles E. North, of New York City, author of an article on "Sanitation in Rural Communities," just issued by the United States Bureau of Education. As the natural intellectual leader of his community, the rural teacher, he maintains, can do for public health in the country what the medical inspector and school nurse are doing in the city—point the way to clean living.

Mere teaching of physiology is not what is needed. Physiology may satisfy the curiosity of children as to their internal organs, but it does not protect them in any way against tuberculosis from contaminated milk or typhoid from impure water. The rising generation, whether in the country or in the city, has a right to be instructed in the first principles of sanitary science.

Far from being too difficult to teach in the elementary school, the subject of public health can be made both understandable and interesting. Such a simple operation as washing the hands, for instance, becomes attractive when studied with reference to bacteria. "Personal cleanliness, purity of food and of drinks, the nature of disease, and the method of transference, are all things which can be expressed in the simplest terms and made clear to the understanding of children," asserts Dr. North. "Milk, its value as a food, the fact that it is highly appreciated by bacteria, and that it is therefore necessary to protect it against them—these are not too difficult for the child to understand."

Dr. North emphasizes the need of special training in this subject for school-teachers. He believes that normal schools and teachers' colleges should have regular courses in public health, so that the country school-teacher may be armed with the essential facts of sanitary science.

Remarkable results may be expected to follow adequate public health work by rural school-teachers. It is estimated that if effective sanitation were enforced the present average of 45 years for human life would be prolonged to 60. "In rural communities annually 400,000 persons die and about 2,000,000 others are seriously ill from infectious diseases. If only one-half of these deaths and cases of sickness can be eliminated, it means that an immense field of useful work lies at the hand of the country school-teacher who will become a public-health educator, and will instruct the children and the mothers and fathers how to prevent the transference of poisonous bacteria from those who carry them to those who do not."

A FIRST STEP IN INDUCTIVE RESEARCH INTO THE MOST EFFECTIVE METHODS OF TEACHING MATHEMATICS.

By A. Duncan Yocum,
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It is the belief of the writer that the way has been prepared for such experimental inquiry into the teaching of the various academic subjects as will result in an inductive science of pedagogy. With the co-operation of the United States Bureau of Education in which he has been made Collaborator, he is attempting first, the formulation of a complete scheme of research for each specialty through the determination of what has already been accomplished and the suggestion of additional experimental problems by experts in each, and second, the furtherance of actual experimentation and research. Incidentally, the dissemination of information concerning the necessary experiments may ensure a more general interest on the part of teachers in the inquiry as a whole and prepare the way for the early application of its results.

At first thought mathematics seems the least promising of all fields for pedagogical research. As the most exact of all sciences, with a precise and logical mode of procedure all its own and a resulting discipline which has secured it pre-eminence in the course of study, pedagogical method seems to coincide with the logical and to offer no additional factors which make for efficiency in mathematical instruction. The partial and tentative list of experiments included in the present article is in itself the completest refutation which can be offered to this point of view. Indeed, while the results of Professor Thorndike's experiments with the carrying over of the habit of exact reasoning from mathematics to everyday life could not have convinced mathematically trained minds that they had not been helped by mathematical training, they should have caused any analytic mind to question whether all the conditions favorable to general discipline are present in mathematical method. As a matter of fact, every teacher of mathematics can testify that there are students who know and can apply some rule for algebraic factoring who can not factor complex quantities, and students of geometry who understand and can demonstrate every theorem in its order who are helpless with original propositions. That is, there are students thoroughly familiar with mathematical method who can not generally apply it within even the mathematical field. Here

the missing factor is purely pedagogical. Given the certain and mechanical association in the mind of the student of the idea which first suggests a mathematical judgment with every possible alternative that completes the various stimuluses of which it is a part, and the analysis and synthesis necessary to independent judgment become possible. For example, if the student of algebra not only knows his rules for factoring but has so associated a^3 with the various combinations in which it has been factored that as soon as he sees it in a quantity, however complex, he has formed the habit of looking for plus a^3, minus a^3 or plus or minus a^2b, etc., the stimulus to a familiar julgment is sure to be discovered. Or if the student of geometry can not only remember and demonstrate his theorems but when two angles are to be proved equal mechanically recalls in quick succession every way in which angles *can* be proved equal, and so on with every other geometrical stimulus which has alternatives, the most serious bar to original geometrical analysis, synthesis, and judgment has been pedagogically removed.

While the expert student of pedagogy is capable of the analysis of pedagogical facts and principles into specific propositions and with partial familiarity with mathematical teaching can plan an incomplete scheme of experimentation determining for the teaching of mathematics, only the expert mathematical teacher is capable of analyzing mathematical aims and subject matter into the details which associated each to each with the appropriate products of pedagogical analysis result in the experimental problems whose sum total constitutes the research scheme as a whole

It is in the hope that the mathematical teachers of America may be willing to co-operate in such pedagogical inquiry, that the following problems are submitted for their criticism and suggestion. That their help will be forthcoming is indicated by the general interest shown by mathematicians in my merely tentative "Inquiry Into the Teaching of Addition and Subtraction" published by the University in 1900, and the courteous acknowledgment recently made by Dr. Fletcher Durell of Lawrenceville of a partial application of some of its conclusions in a recent arithmetical text-book.

It is, of course, understood that the main purpose of this list is to make possible the formulation of a more complete scheme of research through the suggestions made by mathematicians. While it is confined to the field of elementary mathematics, the application of similar pedagogical factors to the teaching of higher mathematics will be especially welcome.

Experimental Problems in the Teaching of Geometry.

I. *Grouping.*—Effect upon the memorizing, retention, comprehension and application of geometrical facts and principles of:

1. The cumulative grouping together of all solutions partially similar in their most important factors, as they are reached in the usual order, vs. the usual order without cumulative grouping. For example, the grouping together of theorems in which super-position is emphasized, those in which lines have to be added or extended, those in which triangles have to be proved equal, etc.

2. The successive study of a whole group of solutions partially similar in their most important factors, wherever such order is not broken in upon by the fact that the solutions are conditioned by others which are not similar and which have not yet been mastered, vs. cumulative grouping by similarity in solution. Cumulative grouping is not only more practicable, but in all probability will be found to be more effective.

3. So defining the various geometrical figures as to group them together through the largest possible partial identity, vs. definition which isolates them from each other. For example, defining a square not only as a rectangle whose sides are equal, but as a parallelogram whose angles are right angles and sides equal, and a quadrilateral whose angles are right angles and sides equal, etc.

4. The specific location of propositions cited in course of solution by book and number vs. citation alone.

II. *Gradation.*—Effect upon the memorizing, retention, and comprehension of geometrical facts, principles and solutions of:

1. Determining the relative difficulty of solutions and arranging them in the order thus determined, in so far as the conditioning of relatively simple propositions by relatively difficult ones, etc., makes it possible, vs. the usual order. It is of course not only possible, but probable, that determination of relative difficulty followed by arrangement under the limitation imposed will result in essentially the usual order.

2. Postponing a difficult and complex solution, wherever possible, until either cumulative grouping (I-1) or the repeated application of the theorems involved in its solution through the successive solution of theorems which similarly involve them (I-2) have made the various parts that form the complex mechanically familiar.

3. Preceding the solution of every theorem by the certain association of each fact that is granted in it, with every significant combination and consequence so far mastered. (See V-3 and V-4.) II-1 and II-2 will probably be found to be very limited in their practicability. II-3 is readily practicable and will probably be found highly effective.

III. *Form of Repetition.*—The relative effect upon memorizing, retention and comprehension of geometrical facts, principles and solutions of:

1. Verbatim memorizing of the solutions with the figures lettered as in the text-book vs. that of the successive steps involved whatever the lettering may be.
2. Memorizing of the successive steps involved in solution vs. the solution of the proposition as an original.
3. The repeated writing of propositions as part of written solution in addition to their oral repetition in oral demonstration vs. reference to them by book and number, or by some essential and identifying phrase.
4. The substitution of actual models representnig the figures of the various solids, for the usual diagrams with dark and light lines to indicate perspective.
5. The use of actual paper-folding in problems involving superposition vs. the mere suggestion of it.

IV. *Interval of Repetition.*—Effect upon memorizing and retention of geometrical facts, principles, solutions and habits of:

1. Varying number of successive repetitions of solutions or other series of relationships in initial memorizing.
2. Upon the interval of repetition in review, of varying number of initial repetitions or varying form of initial repetition of solutions, etc.
3. Continual repetition of the same fact or principle in initial review vs. the same number of repetitions after varying intervals.
4. Upon intervals of review, of varying initial thoroughness —that is, a variable number of repetitions over and above those essential to the first mastery of facts, principles or solutions.
5. Varying intervals in review.
6. Alternation after varying interval with other mathematical study.
7. Continual review at increasingly longer intervals throughout the high school course vs. abandonment of geometrical study for one or more years succeeded by continuous review approxi-

mately equivalent in time and number or repetitions to the continual review.

V. *Conditions Favorable to General Discipline.*—Effect upon memorizing, retention, comprehension and general application of geometrical facts, principles and habits of:

1. The original solution of all geometrical theorems from the very beginning vs. the intelligent memorizing of solutions. Solution is rendered simple in the first theorems from the fewness of the known relationships on which solution must be based.

2. Certain association with a geometrical proposition of either all its applications or a number of the most frequently recurring ones. For example, equality of angles should be associated with triangles, intersected parallel lines and perpendicular intersecting lines.

3. Certain and cumulative association of a geometrical fact with the various relationships which prove it. For example, the association of the fact that two angles are to be proved equal with opposite vertical angles, right angles, alternate interior angles, alternate exterior-interior angles, superimposed angles, angles having parallel sides lying in opposite directions, the basal angles of an isosceles triangle, the angles of an equilateral triangle, etc.

4. Certain and cumulative association with a geometrical fact of all the alternative relationships with which it forms the stimuluses to conclusions. For example, the association of the fact that two angles are equal, with adjacent angles on the same side of a straight line, with all interior or exterior-interior angles, or when a straight line intersects two parallel lines; with including angles having the included side equal, with an isosceles or equilateral triangle, etc. It is of course assumed that the various propositions involved are themselves familiar.

5. The habit of analysis and synthesis on the granting or the recognition of any geometrical fact with which various proofs or alternative stimuluses to conclusions are certainly associated.

6. The habit of drawing various geometrical figures and inferring all possible consequences from given facts.

Experimental Problems in the Teaching of Algebra.

I. *Grouping.*—The effect upon the memorizing, retention and comprehension of algebraic facts, principles and processes of:

1. Such review—preceding the initial mastery of each algebraic process of the indentical process in arithmetic as will make

all pupils conscious of the identity vs. mechanical mastery of the algebraic process. If there is a high percentage of pupils who independently note the identity, the difference in efficiency between the two alternatives may be slight.

2. Such grouping together of partially identical algebraic processes as will make the pupils continually conscious of the partial identity vs. the usual logical order. For example, the putting together of single factors, such as *a* and *b*, in multiplication, the index as indicating the number of identical factors multiplied together, the addition of the indices as determining the whole number of identical factors multiplied together; the subtraction of factors as dividing the quantity as a whole by the factors subtracted, the subtraction of indices as determining the number of identical factors remaining after division.

Or simultaneous drill on the making of equations from statements, and the changing of the form of a complex fraction to a series of simple operations. Here the helpfulness of one process to another would depend upon general discipline. (See V.)

II. *Gradation.*—The effect upon memorizing, retention and comprehension of algebraic facts, principles, processes and solutions of:

1. Gradation involving separate and varied drill from day to day upon each step in a complex algebraic process vs. an equal amount of drill on the same operation as a whole. For example, drill on the mere changing of the form of a complex fraction to a series of operations vs. immediate operation. Or drill on the making of statements for many problems, or the formulations of equations from statements, in place of the solution of problems as wholes. Or drill on seeing whether or not the second term of an expression having four terms with the first a perfect cube, is in the form $3x^2$, however it may be disguised by a numerical coefficient; or whether it is accompanied by another perfect cube plus or minus, etc. vs. drill in looking for familiar cases of factoring as wholes.

2. Drill on each unfamiliar step involved in a complex process for a considerable period of time involving constantly increasing intervals in review vs. more nearly simultaneous gradation.

Few processes in algebra are complex through a combination of difficult and unfamiliar processes, the more complex corresponding to similar operations in arithmetic. An application, however, would be long and persistent drill in the separate mas-

tery of algebraic subtraction, multiplication and trial division, in the form used in long division.

III. *Form of Repetition.*—The effect upon the memorizing, retention and comprehension of algebraic facts, principles and processes of:

1. The explanation of a new process by a purely visual illustrative example vs. explanation in which the teacher progressively developes the visual example as a motor process. That is, illustrative examples already printed in text-books or written on the blackboard as wholes vs. those written by the teacher as he explains the process.

2. The use of colored chalk or underlining to emphasize some separate step in a process.

3. Oral drill in simple algebraic processes as a preparation for written work vs. written drill. For example, in factoring.

IV. *Interval in Repetition.*—The effect upon the memorizing and retention of algebraic facts, principles, processes, solutions and habits of:

1. Continuous repetition in sequence in initial memorizing vs. the same number of repetitions after intervals spent in other work or the repetition of similar material. This factor has its bearing upon simultaneous gradation in which the parts of a complex process are separately drilled upon. (See II-1 and II-2.)

2. Varying intervals of repetition in review.

3. Varying amount of repetition in the days immediately succeeding initial memorizing or varying amount of time and repetition spent in initial memorizing.

6. Alternation after varying interval, with other mathematical study.

7. Continual review at increasingly longer intervals throughout the high school course vs. the abandonment of algebraic study for one or two years, succeeded by continuous review approximately equivalent in time and number of repetitions to the continual review.

V. *Conditions Favorable to General Discipline.*—Effect upon the memorizing, retention, comprehension and general application of algebraic facts, principles, processes and habits of:

2. Certain association with an algebraic relationship of either all of its fields of application or a number of the most frequently recurring ones. For example, association with factoring of least common denominator of fractions and the simplifying of equations.

Or the association of the habit of changing a complex combination of facts or processes into a series of simple ones, with forming of equations from statements, or the simplification of a complex fraction.

4. Certain and cumulative association with an algebraic fact of all the alternative relationships with which it forms the stimulus to judgments or procedures. For example, the successive association of a^3 with $-b^3$, $+b^3$, $3a^2b$, etc., and the possible cube of any number or quantity that may constitute its coefficient or a part of it. Or of the solution of an equation after transposition or rearrangement, with factoring, the completion of the square, etc.

EXPERIMENTAL PROBLEMS IN THE TEACHING OF ARITHMETIC.

I. *Relative Effectiveness in the Derivation and Memorizing of Fundamental Facts of:*

1. Drill upon the fundamental sums in which a sum is constantly substituted for its inversion but not contrasted with it vs. that in which sum and inversion are separately drilled upon. For example, drill in which 6+3 and 3+6 are constantly interchanged with a view to making the pupils conscious of identity rather than contrast vs. separate drill in each.

2. Similar comparison with fundamental products and their inversions. For example, with 6x3 and 3x6.

3. Similar comparison with fundamental differences and their alternations. For example, 6—4 and 6—2.

4. Similar comparison with fundamental quotients and their alternations. For example, 6÷2 and 6÷3.

5. Grouping of the fundamental sum in the order of the digits (Grube order) through identity in the sum vs. grouping through identity in the digit added. For example, 5+1, 1+5, 4+2, 2+4 and 3+3, etc. vs. 2+2, 3+2, 4+2, 6+2, etc. Here both derivations must be either objective or abstract.

6. Grouping of each fundamental difference with its corresponding sum (after pupils have mastered the fact that when two numbers are added together and one is taken away, the other remains) vs. the grouping together of differences having a common minuend. For example, 4+3, 3+4, 7—3, 7—4; 5+2, 2+5, 7—2, 7—5 vs. 7—5, 7—4, 7—3 and 7—2. See experiment IV-11 for effect or readiness of operation involving thorough familiarity with fundamental differences vs. Austrian method.

7. Also vs. the grouping together of differences having a

common digit for their subtrahend (after pupils have mastered the fact that the subtraction of a digit greater by one than a familiar subtrahend leaves a difference less by one). For example, 4+3, 3+4, 7—3, 7—4; 5+2, 2+5, 7—5, 7—2, etc. vs. 9—2, 7—2, 5—2 etc. and 8—2, 6—2, etc.

8. Counting forward or backward by ones, twos, etc. vs. the same time spent in "number stories." Here effect of external interest and motive is compared with that of the greater amount of abstract repetition possible in the same time. The comparative result as affecting application should also be noted.

9. Also a given *number* of repetitions of a fact in counting vs. the same *number* of "stories' in which the fact is applied.

10. Identification of the successive products in each multiplication table with counting in which the digit used as the common multiplicand is the successive addend vs. abstract mastery of the table. For example, 2 and 2? and 2? and 2? etc. vs. abstract drill on 2x2=4, 3x2=6, etc.

11. The breaking up of the multiplication table into individual facts by calling for each in constantly varying order vs. the association of adjacent facts with one already familiar or more readily remembered. For example, miscellaneous drill in the six-table vs. drill associating seven sixes, forty-two and nine sixes, fifty-four with *eight* sixes, forty-*eight;* and twelve sixes, seventy-two with the adjacent but easier eleven sixes, sixty-six.

Grouping of fundamental quotients with their corresponding products vs. their separate mastery. For example, 12÷4 and 12÷3 taught with 3x4 and 4x3 vs.

II. *Relative Difficulty in Derivation, Memorizing and Retentions of:*

1. Miscellaneous sums below ten, and those involved in counting from 20 to 100.

2. Sums involved in counting from 10 to 20, and those involved in counting from 20 to 100.

3. Sums resulting from the addition of 1 to 29, 39, etc. and those resulting from the addition of 1 to any other numbers between 20 and 100. Also as compared with the addition of 2, 3, etc. to 29, 39, etc.

4. Of larger numbers as compared with smaller ones similar in other respects than size. For example, 22+4 as compared with 42+4, 82+4; or 39+2 as compared with 69+2, etc.

5. Of the more closely corresponding fundamental differences as compared with each other. For example, 6—4 as compared

with 7—3 or 9—5; 20—3 as compared with 50—2 or 70—1, etc.

6. Of differences involving the subtraction of 1 from 10 as compared with those involving the subtraction of 2, 3, etc., from a number with a lesser digit in the units place.

7. Of miscellaneous differences compared with each other.

8. Of the products of one multiplication table compared with those of another.

9. Of miscellaneous products compared with each other.

10. Of the quotients of one division table compared with those of another.

11. Of miscellaneous quotients compared with each other.

III. *Relative Effectiveness in Derivation, Memorizing, Retention and Rederivation of:*

1. Mere imitative repetition of a fundamental number fact vs. its objective derivation and repetition by the teacher under the observation of the pupils. Note, in case of the first alternative, the inability of pupils to rederive a forgotten fact. Since mechanical efficiency is an ultimate aim distinct from number perception, is not the effect of this alternative on memorizing and retention the only significant fact?

2. The derivation and repetition of any fundamental number fact through the counting out of objects by the pupils themselves vs. their observation of similar derivation by the teacher.

3. The objective vs. the abstract derivation of the fundamental sums through the addition of 1 to the addend and result of the sums just below them in the series. For example, the objective vs. the abstract derivation of 4+3, 7; 8+3, 11; 6+3, 9; etc. from 4+2, 6; 8+2, 10 and 6+2, 8; etc.

4. Compare relative readiness through the objective vs. the abstract method in the rederivation of forgotten facts or of independent derivation of new facts.

5. Similar comparison of abstract and visual or visual and motor methods in the derivation of fundamental differences.

6. In that of fundamental products.

7. In that of fundamental quotients.

8. Comparison between derivation in which blindfolded pupils derive the fundamental number facts by counting objects which they touch, and that in which they see the same objects counted by the teacher. (Is it not possible that these methods are equalized by visual imagination on the one hand and kinæsthetic on the other?)

9. Oral drill on the fundamental number facts plus repeated writing of the fact in algebraic form vs. oral drill alone.

10. Abstract drill on the number facts vs. their repetition in number stories.

11. Concrete derivation of the fundamental fractional parts with the aid of squares, circles, etc. vs. abstract derivation by corresponding fundamental quotients.

12. Of thorough familarity with the derivation of a rule or principle vs. its verbatim memorizing.

13. Verbatim repetition of a rule, principle or definition vs. its repetition variously expressed.

14. Its visual vs. oral repetition.

15. Its visual and oral vs. an equivalent number of oral or visual repetitions.

16. Its motor vs. oral or visual repetition.

17. Its motor and oral vs. the same number of oral, visual or motor repetitions.

18. Its motor, visual and oral vs. the same number of oral, visual or motor repetitions.

19. Definition vs. definition plus pictorial representation of the thing defined.

20. Definition and pictorial representation vs. the actual use of the things defined. For example, the actual filling of a quart measure by two pints, or school banking and business operations involving the actual use of business papers.

IV. *Relative Efficiency in Written Arithmetical Operation of:*

1. Oral or written drill on naming the places to the left or right of units.

2. Oral drill on the fundamental sums vs. drill in which a written digit is added to a number orally given. (Direct preparation for addition in column.)

3. Oral vs. visual drill on the fundamental differences.

4. Oral vs. visual drill in multiplication not involving carrying.

5. In judging whether there are any units to carry or not, and if so, how many?

6. In dividing tens and hundreds by any digit which does not go evenly into the tens or hundreds.

7. Objective drill in getting the common denominator of simple fractions vs. the oral multiplication of each factor of their denominators taken once. Both from the standpoint of the small fractions and as preparation for written operation with more complex fractions.

8. Oral vs. written drill in the various steps involved in trial division.

9. Drill contrasting facts readily confused owing to their involving identical digits together with those adjacent in the number scale vs. drill in which they are not contrasted. For example, 6+2 with 6+1, 9—4 with 9—5, or 6x5 with 6x4, etc.

10. Drill contrasting number facts not so readily confused vs. that in which they are not contrasted.

11. Of the so-called "Austrian" system of subtraction in which the difference is determined as the number which added to the subtrahend will equal the minuend vs. subtraction in which the fundamental differences are readily used.

V. *Effect on Initial and Permanent Retention of:*

1. Continuous repetition of number facts in direct sequence in initial memorizing vs. repetition after short intervals which are taken up with repetition of other facts.

2. Varying periods or methods in initial memorizing of number facts.

3. In that of complex numerical processes.

4. Continuous drill for a week or so after initial memorizing of number facts has been accomplished vs. review after varying intervals.

5. After memorizing of complex numerical processes.

6. Of varying intervals of review for number facts after the period of initial review.

7. For complex numerical processes.

VI. *Effect on Memorizing, Retention and Operation of:*

1. Initial drill or review in which the number of facts is variously limited to a minimum readily mastered vs. miscellaneous drill involving all facts in addition, subtraction, multiplication or division.

2. Drill on a single step in a complex process with a large number of examples followed by similar drill with each other step vs. the same amount of time spent in simultaneous drill on the whole series of steps.

VII. *The Effect on General Application of:*

1. Objective vs. abstract derivation of the number facts.

2. Abstract repetition of the number facts vs. their repetition in "number stories." (This effect can be noted in III-1, III-3 to III-7 inclusive, and III-10 without separate experimentation.)

3. Repeated application of the principle in general form vs. the same amount of application of specific rules.

4. Repeated application of the general principle vs. such application plus the association of a few typical applications. For example, association with the judgment "more" as the signal for addition, of such common experiences as finding, being given, getting, making, taking, buying, etc. Or of base in percentage with cost, amount of sale or purchase, par value, etc.

5. Thorough mastery of the terminology figuring in the common applications.

6. The identification of a given term in a large enough number of problems to ensure its identification in any one vs. the same amount of time spent in the complete solution of as many as possible of the same problems.

7. The habit of analysis in the sense of identifying all given terms in a large number of problems vs. the same amount of time spent in the complete solution of as many as possible of the same problems.

8. The habit of synthesis in the sense of variously combining the terms thus identified until the familiar signal for application results.

9. The habit of progressive analysis and synthesis in the sense of identifying and combining all terms anew after each new term resulting from successive judgments in the indicated solutions of a complex problem vs. the same amount of time spent in the actual solution of as many as possible similar problems.

10. The habit of discovering new applications.

11. Oral drill with a new set of fundamental facts to be applied in written operation, after a similar set of facts has been drilled upon visually by the same class. For example, after the effect of oral vs. visual drill in judging whether or not to carry in multiplication is noted with different classes, it should be determined whether the class given the visual drill will visualize without visual drill a new set of judgments orally drilled upon.

VIII. *The Effect Upon Number Perception of:*

1. Objective derivation of numbers from 20 to 100 and their abstract derivation through mastery of the fact that 1 added to a number gives the next above it in the counting scale, and of twenty, thirty, forty as short ways of saying two tens, three tens, etc. (Do pupils know without visualizing that 60 is greater than 40, or 45 than 41 or 22?)

2. Attempting to teach pupils to discriminate without estimation between variously arranged groups of five, six or seven identical objects. Are four or five the limit to the number of

objects that can be instantaneously perceived at a time? Is it not possible that groups of even three, four or five objects are recognized either by familiar forms of grouping or unconscious estimation so rapid as to be practically instantaneous? If so, *can* pupils visualize numbers except in some specific grouping, through the space occupied, etc.?

3. Frequent measurement to check the approximate correctness of estimated size, capacity or distance.

Of course, universally valid results for experiments such as these, finally determining for mathematical teaching, can be reached only by experts through rigidly scientific research in which sufficiently large groups of students are represented to eliminate individual variation. But reports on any experiment which a teacher has tried with parallel classes, in which a single factor in method has been varied, with other factors and conditions kept as uniform as practicable, will be most acceptable. These, with all suggestions of additional problems for experimentation, will be carefully examined and classified and, if found available, published with due credit to the sender. They can be forwarded me either through the Division of School Hygiene, Bureau of Education at Washington, or direct to my departmental address, College Hall, University of Pennsylvania.

MODELS FOR TEACHING SOLID GEOMETRY.

For constructing skeleton models of cubes, octohedra, etc., wooden rods with needle-pointed ends are sometimes used, the ends being fixed into small pieces of cork. Such a method has, however, a great disadvantage in that the joints are not flexible, and it is difficult to adjust the rods to the required angles. A joint which is stiff and the angles of which can be varied easily is wanted. I have found that models can be quickly and accurately put together by the use of the following simple apparatus.

Cut three pieces of 16 S. W. G. copper wire, each 2½ inches long, hold them together, and bind them round the middle with about ten turns of 22 S. W. G. copper wire. Touch this part with a little solder, and then cut into two equal lengths. By bending the ends of the wires outwards two little tripods are obtained. A supply of three- and four-legged pieces is required.

From the toyshops or ironmongers round wooden rods about 5/16 inch diameter can be obtained, which are sold in 4 foot lengths at 10*d.* a dozen. Cut them up into lengths varying by 1 inch, the largest 15 inches, the smallest 10 inches, and with a twist drill rather smaller than 16 S. W. G. make a hole at each end axially.

By inserting the legs of the tripods, etc., into these holes any framework can quickly be built up.

By rolling a piece of thin brass round one of the rods a split tube can be made with which rods can be joined telescopically and any length obtained.—*The School World.*

ON THE PSYCHOLOGY OF ERRORS IN ELEMENTARY MATHEMATICS.

By Thomas J. McCormack,
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(Continued from February Issue.)

Asymmetry.

I will revert now to the physical character of our sense-organs in another form. From our studies of physiology and psychology we all know that the physical symmetry of our organs of sense and of perception is not perfect. The two eyes are very symmetrical; our organs of hearing are fairly symmetrical; our hands and our motor organs are unsymmetrical in power. The brain is asymmetric, a fact which has led, it is thought, to our being right-handed or left-handed, right-footed or left-footed. Just as we are right-handed so we are slightly right-eyed, and oriented generally towards the right. We and all right-handed nations read and write from the left to the right. It has always been a fancy of mine that the Hebrews and the Semitic races were originally left-handed, and consequently wrote from the right to the left. If we lived on the interior surface of a sphere, as some ancient astronomers thought, our sense-organs might have been so developed as to produce a sort of centripetal geometry. Such a people could have invented only polar coördinates. The geometry of the Cyclops of Homer who had only one eye, and the geometry of a fictitious race of bird-men and horse-men who had their eyes on the sides of their heads might be conceivably different in its physiological properties from ours. The chief point I have to make in this connection is that our physiological and psychological one-sidedness is the source of many difficulties in elementary instruction. I will cite only one, the difficulty, namely, that we all have in making students see that we can solve an equation just as well when the *x's* are on the right-hand side of the equation as when they are on the left. I, myself, did not acquire this facility until I reached manhood, and I am still conscious of a slight intellectual effort when I make the deduction that from $6=3x$, it follows that $2=x$. In other words, we are right-headed as well as right-handed.

Intellectual Symmetry.

Corresponding to the symmetry of our sensations of space

and to the symmetry of our acts of motion and sensations of motion, we shall find, thus, that there exists in the mental realm an analogous species of intellectual symmetry. The motor acts of the eyes, of the hands, and the energies corresponding thereto, must necessarily condition definite corresponding and parallel psychical habitudes. So with the repetition of spoken words. Every motor act or impulse, every spoken word, leaves its memory-trace. Just as there is a parallelism between physical phenomena of sound and the fibres of Corti, so also there must be a parallelism between the modes of operation of the sensory organs or of our verbal mechanisms, and the intellectual or psychical acts that accompany or are evoked by them.

Time forbids me to go into details on this point. I shall merely instance in this connection those errors which arise from the mind's taking on certain mechanical habits of action that cause our thoughts to run from sheer momentum in grooves parallel to certain traditional and stereotyped word-forms like the axioms. The repetition of familiar word-forms such as the axioms will, like the replies to questions in a catechism, form thought-grooves, thought-patterns, or thought-models which soon assume independent reality and acquire independent habits of operation entirely disconnected with the facts. So deeply ingrained are these word-patterns in our intellectual structure, that it requires considerable effort of inhibition to prevent new material from running automatically into the same moulds. If the new words or the new proposition start in the same stereotyped manner as the old, the entire new statement is very apt, if it hits the stereotyped thought-forms in question, to be carried automatically along in those forms. The general symmetry of the thought-form automatically drags with it or superinduces upon itself a verbal symmetry that may enunciate flagrant error.

I will give here a very striking instance of this error, which may be explained as due to the automatic momentum of thought-forms carrying new and parallel verbal material into fields where it is not applicable, being the confusion due to verbal and intellectual symmetry just as sense-confusion results from physical symmetry. Consider the following verbally symmetrical propositions and axioms, and note the intellectual automatism forced upon us by their word-forms.

"Magnitudes equal to the same magnitude are equal to each other." "If equals are added to equals, the sums are

> equal," etc., etc. "Two lines parallel to the same line are parallel to each other."

And, now automatically and triumphantly (you have all experienced it), *"Lines perpendicular to the same line are perpendicular to each other."*

I believe we have here the most beautiful possible example that could be selected of the error or confusion that results from verbal symmetry inducing intellectual symmetry. This error occurs in both geometry and algebra in a dozen different illusive forms. I believe we have discovered here the origin and the cause of it. We call it in ordinary parlance "Talking without thinking." But right here precisely is the difficulty. Almost the entire object of instruction is so to shape our mental activity that we *shall* talk and write automatically, without error, correctly, and in accordance with the facts. Whenever we can substitute a flawless piece of automatic talking mechanism for a thinking mechanism in any individual person, then we have to that extent instructed him. As I repeatedly emphasize in this paper, our main endeavor in cumulative mathematical instruction is to get rid of thinking and to substitute automatism for thought, *so as to economize and to conserve our conscious intellectual labor for higher ends.*

Language and Scientific Method.

We are here, in the question of verbal automatism, dangerously near the question of the origin of language, and I only wish that I had the time at this point to discuss Condillac's theory of science, which makes a perfect method, whether in physics, sociology or mathematics to consist in a perfect language. I believe that all that Condillac meant was that if the correspondence between the technical language and reality were perfect, then the manipulation of the language would give us the facts of reality, as in the case of mechanics and mathematics it actually does, where we can, from merely manipulating a verbal rule or symbolic formula, reconstruct and reproduce the facts of nature. In geometry especially it would seem as if our technical language contained *in nuce* all the truth which the machinery of deductive logic afterwards extracted from it. It sometimes seems to teachers and students that all that it is necessary to do to solve the simplest propositions and problems is to translate the words or word-symbols into visualizable images. For

example, whenever we replace for the word perpendicular the equality of the angles on each side of it, we solve at once some of the simpler propositions, and so have reached the truth simply through the automatic development of a perfect technical language. This is what the great Pascal meant by his famous rule (a rule which is now hardly known and scarcely ever applied by teachers of mathematics), namely, that the first step in solving any problem is *to substitute the definition for the thing defined.* For example, I have frequently had students stumble over simple problems like the following: "The inclinations of two parallel lines to a plane are equal." The mere direction to substitute for the word-form "inclination to a plane," the definition of inclination to a plane leads easily and speedily to the solution.

This is but one facet of the world-old question of the metaphysics of logic as to whether mathematics ever leads to essentially new truth; whether its elements are not embryonically contained in the word-forms and thought-forms from which it started. We are not concerned with the solution of this metaphysical question. We are merely taking advantage of one of the intimations which its discussion obtrudes upon our notice.

On Confusion Through Similarity of Rules.

Similarity of rules demanding similar motor acts in algebra leads to confusion just as physical symmetry does in the visual and motor domain. The rule *"to clear of fractions"* in equations is carried by the verbal and motor automatism of which we have just spoken *over* into the domain of *the adding of fractions* where by error the denominator is omitted. There is confusion of reason through similarity of rules and motor directions here quite analogous to the confusion of sense through visual and motor symmetry.

Nearly all the rules we are considering *substitute* sheer mechanical, verbal and motor devices for intellectual acts. The operation of *cancelling* is the substitution of a motor act for an intellectual act. A single motor act is sufficient when there is only one term in the numerator and denominator. But the motor mechanism of the learner appears to lose its momentum when the numerator or denominator contains several terms. If the rule were first learned where the numerator or denominator was a polynominal, the error might not have arisen. Or perhaps the direction of the motor tendency is the cause of the error. One

teacher at our last meeting said that he taught his scholars to make the cancellations altogether by horizontal strokes. This is quite in accordance with our theory of the automatic momentum or inertia of motor and intellectual acts. If the rule is taught in *association* with the image of a definite *horizontal* motion, then the direction of the motor act is established and carries the operation through all the terms. All these rules are mechanical devices and tricks and have in them no intellectual content. Any such motor device as that suggested by the teacher in question is therefore permissible. It is comparable to bringing objects within the range of vertical symmetry in geometry, and is opening the field to motor symmetry in the development of the mechanical rules of algebra.

I will leave to you the application of these principles to the explanation of some of the typical errors you may have encountered in practice. (See the *Mathematics Teacher* of Syracuse, New York, number of March, 1910.)

THE REMOVAL OF SENSE-OBSTACLES IN GEOMETRY.

I have frequently remarked that the only advance made in the didactic presentation of the principles of geometry in two thousand years is the reduction of the verbiage of the old elements and the economizing through concise language and shorthand symbols of the linguistic form in which the propositions were presented and proved, that the advance consists almost entirely in a progressive economization of sensual presentation, in the removal of sense-obstacles. I have myself personally passed through this evolution of two thousand years, because as a boy, after the English fashion, I studied geometry in the form in which it was presented in Todhunter's "Elements of Euclid," studying later the elements of Lacroix and Legendre, and then the modern books. The matter of Euclid was for centuries unrelieved by a single device for economizing visual or intellectual presentation. We know of only one precaution taken by the Greeks that reminds us of the devices of the modern textbooks and that is the one mentioned by Cantor as having been used by Euclid himself namely, that the letter "iota" or "I" was never employed in lettering figures for the reason that it was apt to lead to confusion with the straight mark or line. Of the vast number of economic devices which we now have for concentrating the field of vision and for fastening the attention upon central points and for preventing the mind from roaming with the

senses, there was not a trace. How anyone can now refuse the assistance which the use of brackets, the use of small letters for lines, of Greek letters and numbers for angles offers to us in our intellectual work, is to me incomprehensible. Disturbances of the senses have always their analogue in disturbances of the intellectual acts which accompany and shadow them. Success in mathematical instruction is dependent, step by step, on a progressive elimination of the obstacles presenting themselves to sense and then upon the economization of the verbal and sensory machinery by which the concepts enter the mind. How many teachers have ever thought of the difficulty caused in the teaching of fractions by the fact that the words "numerator" and "denominator" which must be used thousands and thousands of times in the instruction, contain nine syllables.

It may be remarked here that even the motional devices used by Plato (which are merely the mechanical attainment of sense-symmetry), and even the Platonic analysis itself for the solution of geometric problems, waited until the last century for their full exploitation in our text-books.

The Principle of Continuity.

Let us look at these conclusions finally from another point of view. The principle of the permanence of the forms of operations which Peacock and Hankel applied with such fruitfulness to arithmetic and algebra and which has been called by Schubert "the principle of no exception" has its analogues in every field of intellectual activity. It is the method and the basis of most physical inquiry; it consists in holding fast to a truth, a law, or an operation demonstrated in a known and familiar field, and in pushing it in all its operational consequences and implications into an unknown and unfamiliar field. It led Galileo, in one of its most beautiful instances, to the discovery of the law of inertia, and Newton, in an equally beautiful example, to the discovery of universal gravitation. It is commonly termed in these fields the *principle of continuity,* and figures under this name, as a heuristic device in many of the genetic chapters of recent text-books of geometry. It holds in the domain of language and of symbolism; and one of the most notable instances of its application in this direction is in the development of our system of mathematical notation. Persons familiar with the history of mathematics will recall numerous instances where adherence to it has led to momentous discoveries, of which the most con-

spicuous example is the daring employment that Euler made of imaginary exponential quantities.

But the principle of continuity is not restricted to research; it is a fundamental law of our mental and psychical constitution, a biological *sine quâ non* of the struggle for existence, and is employed in the most varied and commonest fields of human and animal activity. The astronomer who follows in thought a disappearing satellite, and the dog that envisages a vanishing cat are alike following the law that led Galileo, Newton and Euler to their astonishing discoveries. It is the principle of continuity, under various forms, that we have been following in this paper. For our present purposes we might better term it under another aspect, "the law of intellectual momentum, or inertia," or, perhaps, under still another aspect, the "law of intellectual automatism," for it is to be remembered that the description is indifferent so long as we grasp the meaning and so long as the analogy we adopt illuminates the processes we are considering.

Let us see, then, what these laws accomplish. Let us see how these laws of intellectual automatism and intellectual momentum, two principles, originally the outcome of intellectual, and, I might say, of biological necessity, and initially forged for the conquest of truth, led by their excess to error.

The Law of Intellectual Automatism.

It is the purpose of all science to replace experience. A scientific law is an intellectual working-model which is substituted for the facts in any given domain, and on which the course of the facts can be reeled off automatically by purely intellectual mechanical operations. The discovery, or the truth, of the law consists in the demonstration, inductive or deductive, of the parallelism or one-to-one correspondence between the working model, the intellectual machine, the rule or the formula, and reality. The law of the lever, the law of refraction, the law of falling bodies, are mathematical machines that take the place of the facts; we substitute for the necessary relations of nature the automatic determinism of a formal mechanism; we work the machines and get the facts; we give the mechanisms their automatic course and get the relations. The formula for quadratic equations replaces automatically the operations necessary for ascertaining the roots; determinants substitute a purely mechanical spatial device for the complex conscious intellectual acts necessary for combining properly the coefficients; the binomial

theorem supplants multiplications with a visual, verbal direction; the slide-rule and the calculating machine symbolize the loftiest formal ideals of science, the substitution of an automatic, self-working mechanism for laborious conscious thought. It is the object of science in this aspect not to think but to get rid of thinking-over-again things already thought out, and so to economize the whole domain of intellectual effort.

In the mathematical field this point of view is so simple and self-evident that it may be taught with the most illuminating effects to the youngest students. I have personally presented, in connection with the rules of algebra, this central and very practical principle of the philosophy of science to secondary students with results that are both delightful and stimulating. For the traditional appeal "Try to think" I have substituted the advice "Try not to think," or rather "so study that you will not *need* to think," "relegate to the subconscious automatic realm the processes that are tried and proved, and *save your surplus thought for the intricate relations and operations that have not yet been subjected to that realm.*"

Plainly this is the object of the largest part of our teaching and drill in algebra—automatism of operation, based on a universal certainty demonstrated once for all for given domains of the universe of forms.

If we see clearly what this function of intellectual automatism or momentum is for the attainment of truth, we shall understand more readily what the same procedure, by its excess, involves for error.

I wish that space permitted me to cite from the history of physics some of the startling metaphysical errors to which the principle of continuity or the momentum of a discovered law has led, when applied to provinces in which it has lost its validity. Neither have I the time to apply in detail this principle to the explanation of some common errors in mathematics. If in this paper I can merely hint at the general nature of the explanation, I shall feel I have done my part; for it is my purpose rather to initiate an investigation and to supply a stimulus to systematic thought on the subject, rather than to exhaust the entire field of inquiry.

In fine, the process we are considering is this: For the facts of nature,—here the relations subsisting between forms and magnitudes,—we substitute a machine, a spatial, or even a verbal device, a rule, a formula, and assume an exact parallelism be-

tween the automatic operation of the latter and the actual realities of the former. The parallelism may or may not be perfect. The full scope of the automatism of the one may or may not be coincident with the entire domain of the other. But we have control of the automatism; we set the substitutional device or machinery a-going and it goes with an independent momentum of its own that usually in mathematics carries us to truth, but may, if the parallelism for any reason fails, carry us to error.

I may quote again in this connexion, Euler's pregnant remark that, in his mathematical researches his pencil seemed to be possessed of a superhuman intelligence and power and to carry him unthinkingly on its wings to uncanny consequences; and the teacher of algebra may often have been tempted to parody Omar's famous lines:

"The moving pencil writes, and
  Having writ, moves on;
Nor all your analytic piety, nor logometric wit
Shall lure it back to cancel half a line,
Nor all your algebraic tears wash out one mark of it."

So great is the power of our science. Yet its very strength is its pitfall. For the momentum of which I speak may be a momentum for error as well as truth. The device, the rule, the formula will run accurately, whether its direction be correct or mistaken, whether its application be inapt or well-chosen. The man in the switch-tower may send the locomotive to Mobile or to San Francisco. The selection of the switches is a different problem from the running and the construction of the locomotive. Both problems enter into successful teaching. They should not be confounded.

A NEW METHOD OF EXPLORING MAGNETIC POTENTIAL AND FORCE FIELDS AND ITS APPLICATION IN THE DEVELOPMENT OF THE POTENTIAL CONCEPT.

By Reinhard A. Wetzel,
College of the City of New York.

References—Clerk-Maxwell's *Electricity and Magnetism,* and Faraday's *Experimental Researches in Electricity.*

Apparatus—A smooth board of pine or other soft wood, about 30 x 40 cm.

A little bee's wax.

Draughtsman's transparent drawing cloth, 21 x 30 cm.

A sheet of drawing paper that will take ink, 20 x 30 cm.

Two bar magnets.

Four brass pins.

Sharp pointed lead pencil.

A one-centimeter magnetic compass with a brass pin soldered upright to the compass box at *E,* the pin point extending about an eighth of an inch below the bottom of the box. (Fig. 1.)

Method—Fasten the drawing board to the laboratory table by means of a little wax under each corner.

On top of the board pin the drawing cloth.

On the cloth place opposite poles of the magnets ten centimeters apart so that the principal axis passing through both magnets is parallel to, and five centimeters from the long edge of the cloth.

Place the compass anywhere in the field between the two magnetic poles. The head of the pin may serve as a handle while the pin point, pushed through the cloth, into the board, locates a definite point in the field. With the pencil rotate the compass box about the pin as an axis, until the magnetic needle is perpendicular to the line from E to W.

Close to the compass box and directly below W make a small pencil dot on the cloth. This pencil dot determines a second point in the field under investigation.

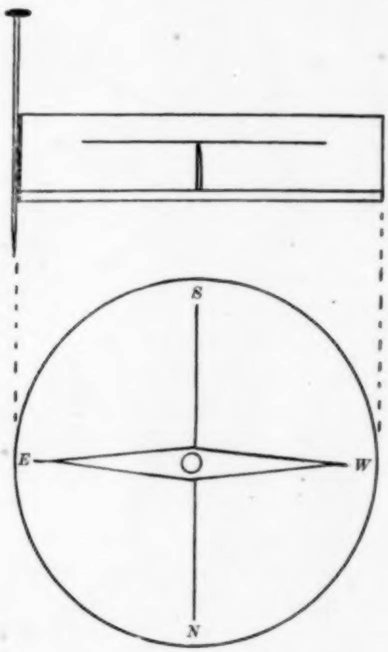
Lift the compass box and push the projecting pin into this second field point. Rotate the compass box as before and find a third point in the same way as the second point was found.

Continue in this way until you arrive at the edge of the cloth or a magnet.

Begin again at the starting point and explore in the opposite direction as far as the cloth's edge or magnet will permit.

With your pencil draw a smooth soft curve through all the discovered points. The curve has been named an equi-potential line from the fact that the potential energy, due to the presence of the two magnetic poles, is the same at every point along the equi-potential line.

In similar manner explore the entire field until the drawing sheet is filled with equi-potential lines about a centimeter apart. Letter the drawing "Potential Field." Except for the inking the drawing is now finished and can be removed from the board.



What Meaning Can We Attach to the Potential Field Which We Have Drawn?

The North Pole has, by convention, been considered as the point at highest potential; whence the South Pole becomes the point at lowest potential.

What would we experience if we carried an isolated North Pole about in this potential field?

An isolated magnetic pole has not yet been found in nature but we may approach its reality in a long magnetized knitting needle where the poles are so far apart that they do not prac-

tically affect each other. The needle may be imagined at right angles to the table, with its North Pole in the plane of the drawing.

If we imagine our hand carrying such an isolated North Pole from the south toward the north field pole, by any path whatever, our hand would do work against the repulsion of the north and the attraction of the south field poles. And there would be no difference between the kind of work done here and the kind of work we have all done in carrying a stone farther and farther from the earth's center where the gravitational potential is zero.

As the lifted stone, when released, comes back to earth so this isolated magnetic north pole when freed from restraint moves back to points at lower and lower potential until it again arrives at the south field pole.

Dr. Ehrhardt[1] of Karlsruhe, Germany, has succeeded beautifully in showing this behavior of a knitting needle by sticking the needle through a light cork and floating it perpendicularly in a vessel of water so that the isolated north pole was directly between the poles of a strong electro-magnet.

Michael Faraday called the path along which such a released pole moved, from points of higher to lower potentials, a "line of force," and the drawing containing all the possible paths, or "lines of force" fields of force. As lines of force and force fields are convenient tools of thought in the construction of magnetic machinery many engineers and physicists have endowed them with considerable reality. Faraday himself thought lines of force were as real as fence rails but sixty years of experimental research still limits their reality to the field of thought.

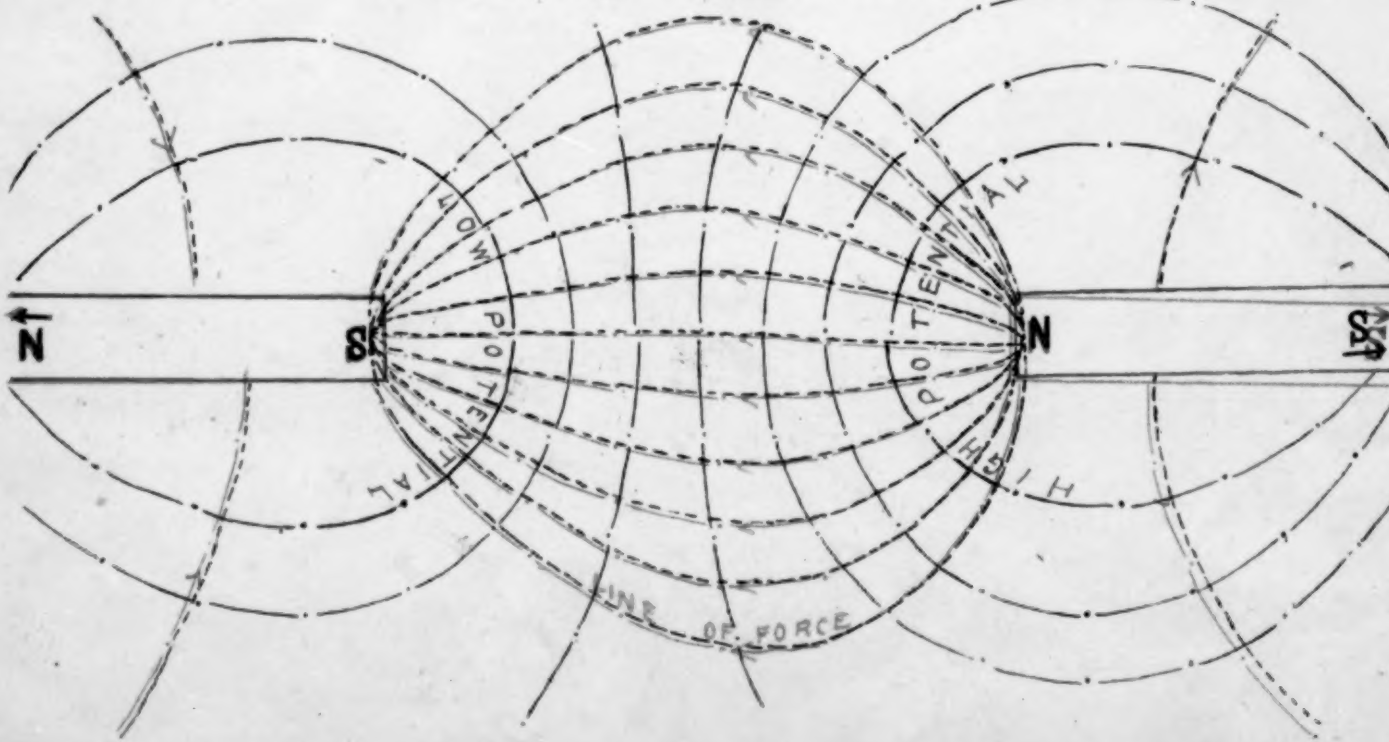
Modern men of science prefer to endow with *energy* rather than with *force* regions like those around the earth, around a magnet, around electrified matter—space in which bodies of respectively similar kinds, *i. e.*, a stone, a magnetic pole, or a charged pith ball, undergo motion when released.

In popular writing "force" is still a synonym for energy but no one today would write for the title of his book what Helmholtz wrote sixty-five years ago when he published his famous memoir *Die Erhaltung der Kraft* (The Conservation of Force).

With energy in the field between two magnets it is easy to get a concept of lines and surfaces along which the potential has the same value, and that when a body moves it is the difference of potential—a definite energy—which is manifested in work

[1]Zeitrchrift für den physikalischen und chemischen Unterricht, 24:271 (1911).

POTENTIAL FIELD



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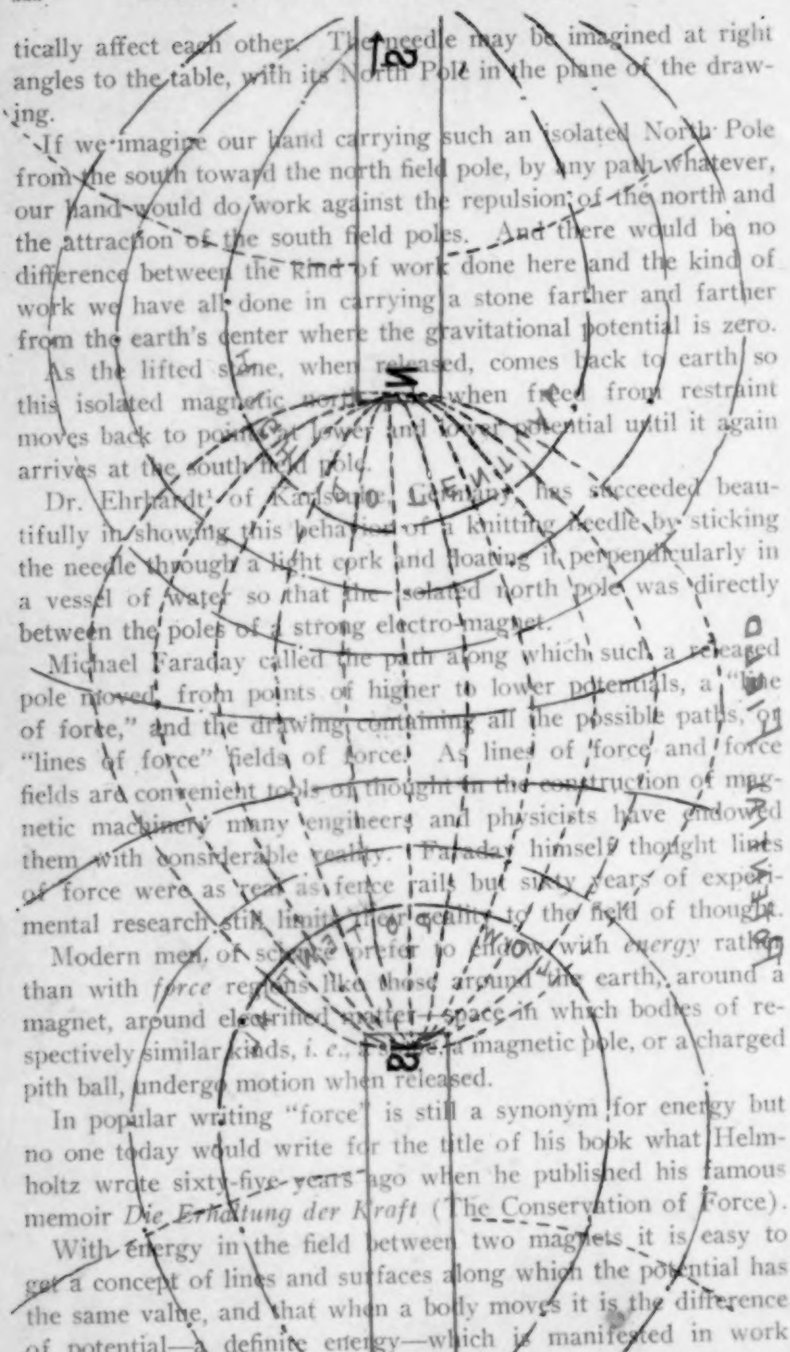
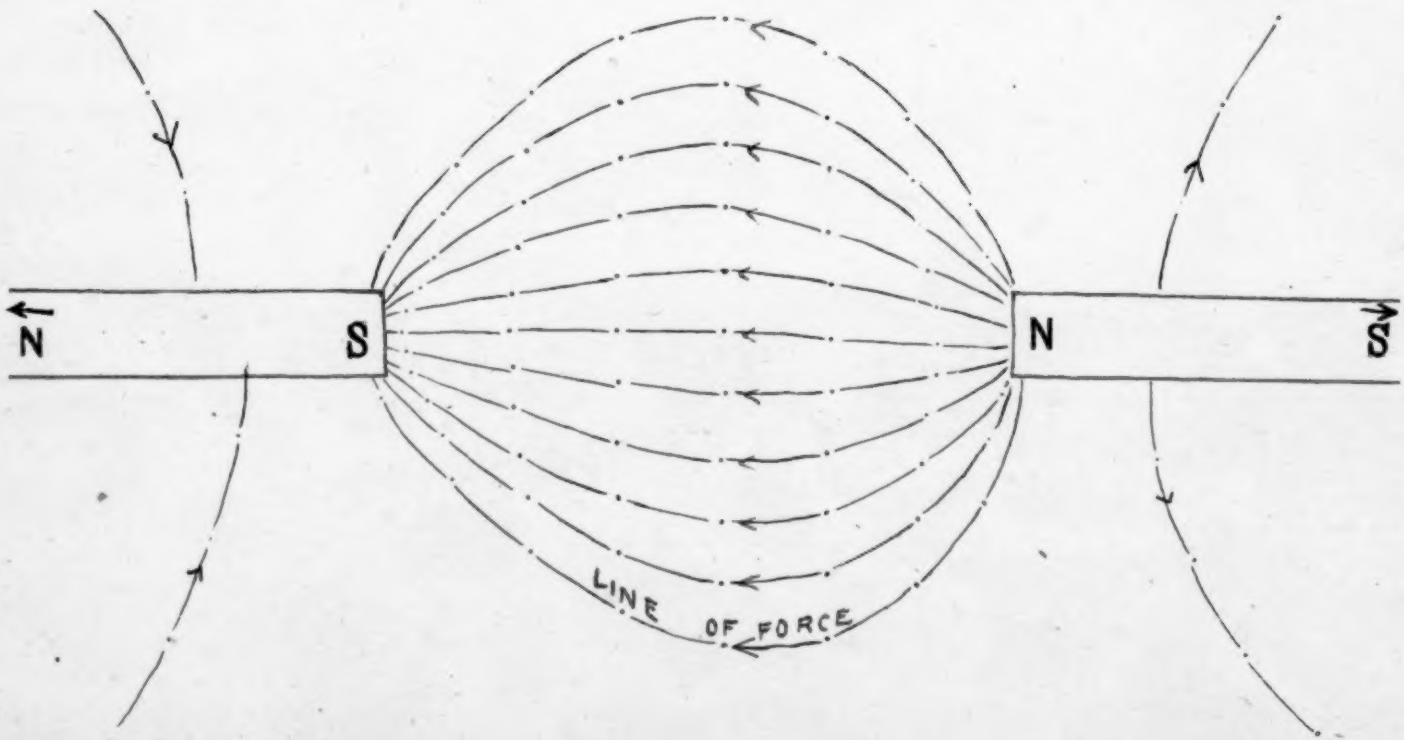


[1]Zeitschrift für den physikalischen und chemischen Unterricht, 24:271 (1911).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LINE OF FORCE

done. Of course if there is no difference of potential between two points there is no energy available for work.

If "lines of force" be considered the name for the path along which a released body in a potential field moves they will have simple, sufficient and practical reality.

Clearing our concepts in this manner of archaisms, we have not solved the mysteries of science which charm the popular mind and thrill the restless blood of explorers. When a stone, for example, is lifted we believe that the energy of motion which carries the stone up is stored somewhere as potential energy; but whether it is stored in the stone, or in the field between earth and stone, or in both no one yet knows as an experimental fact. Neither can science in its present stage tell the real location of the potential energy when an isolated north pole is "lifted," *i. e.,* is carried to higher potential points in a magnetic field. This mystery, however, worries the practical man, the magnetic engineer, as little as it does the man who operates the pile driver. The fact that it works is sufficient. "Does it work" has become the criteria of all scientific as well as practical men.

How To Draw a Faraday Force Field.

Pin the drawing paper to the board of soft wood.

Place the two magnets in the middle of the drawing paper in exactly the same position they had in the potential field.

Push the pin on the magnetic compass again into the board anywhere in the field.

Rotate the compass box until either pole of the magnetic needle points toward the pin.

Place a pencil dot on the paper as near as possible to the pole which is directed away from the pin, as near as possible to the compass box.

Lift the compass and push the pin into this located pencil dot and continue in this way until you arrive at the edge of the paper or a magnet.

Begin again at the starting point and explore in the opposite direction.

Draw a smooth soft curve approximating all of the located points.

In this way the entire field may be investigated and finally lettered "Faraday Force Field."

In inking potential and force fields different colors are suggested.

The width of the drawing cloth for the potential field was chosen greater than that of the drawing paper so that when the two fields were superimposed the extra surface of the cloth might be folded around the edge of the drawing paper and firmly pasted. The result obtained merited all this cost and pains. If the drawings do not show the symmetry in Maxwell's master work, they will be all the more interesting. The copies text-book writers have made of Maxwell's originals are legion and except for the errors of the copyist, they are all alike. As magnetic poles are seldom of equal strength and symmetrically located an infinite variety of fields are obtainable by a class. That all show the facts correctly will be easily apparent from the perpendicularity of potential and force lines.

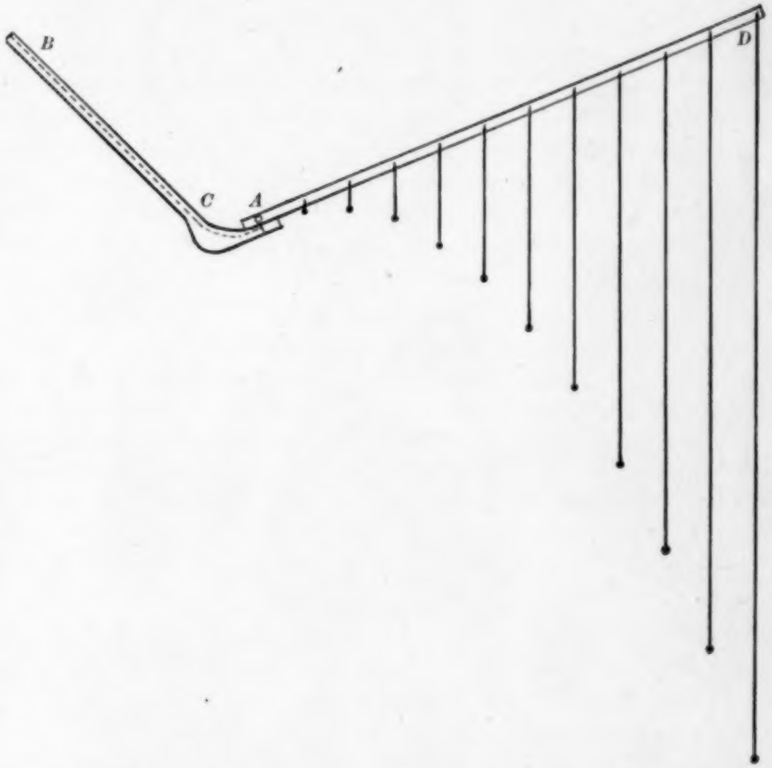
NOTE ON A DEVICE TO ILLUSTRATE THE PATH OF A PROJECTILE.

By J. H. C. Bagby.
Hampden-Sidney College, Virginia.

Many years since the writer, following the suggestion, it is believed, of Prof. Francis H. Smith, of the University of Virginia, constructed the device described on page 194 of the March (1912) issue of School Science and Mathematics. The teaching value of the device is much increased by the following addition to the apparatus: To the rod carrying the threads and bullets is attached a grooved track BCA. The first and greater part of this track, BC, is straight and inclined at about 20 degrees to the vertical when the rod AD is horizontal; the latter part is curved with the end tangential to the length of the rod. This track is so adjusted that, when a polished steel ball, the projectile, is allowed to roll down, the ball will leave the track just opposite the point A, its center, passing immediately over the point A. A few trials will determine the point on the track BC at which the projectile must be freed in order that it may pass by the suspended bullets.

When the student is thus enabled to see that the projectile does in fact pass through each of the points determined by theory and marked by the bullets, he is far more apt to appreciate the cogency of the argument employed in finding in advance the positions of these points. Without such a demonstration the argument too often falls upon barren ground.

An additional device often used with this apparatus may be of enough interest to deserve passing notice. The rod AD is set in a horizontal position and on it is placed a light movable carriage supporting a small electromagnet; this magnet holds a small steel ball, which, on breaking the circuit, may be caused to fall along any one of the threads. Just over the point A is placed a light contact breaker which is opened by the projectile as it shoots



from the end of the track, thus releasing the small ball at the same instant and at the same level. If the adjustments have been properly made, the projectile and the freely falling ball will meet in the air opposite the bullet at the end of the corresponding thread, thus showing the student in a—literally—striking way that the projectile is acted on by gravity to just the same extent as is the freely falling body.

A UNIQUE DEMONSTRATION OF BOYLE'S LAW.

By Albert E. Hennings,
University of Chicago.

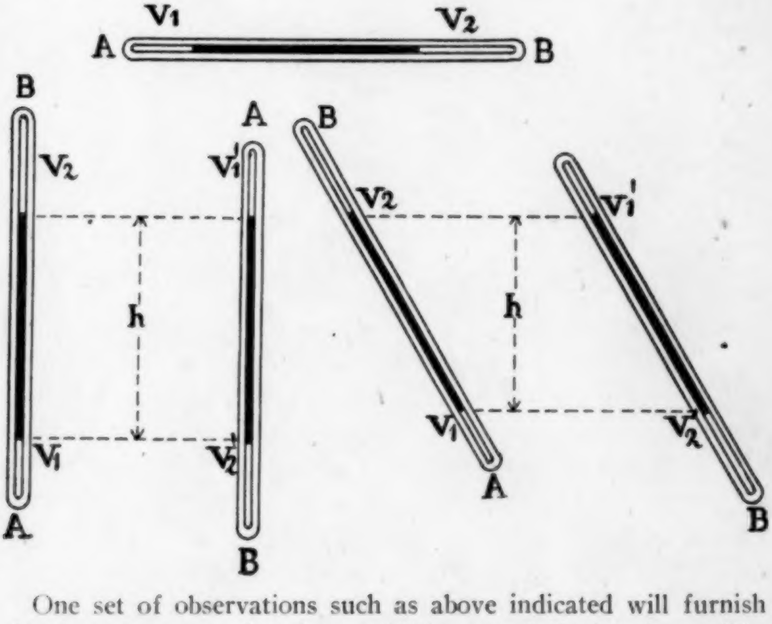
The demonstration which follows is so interesting analytically and so simple experimentally that it seems unnecessary to offer any apology for presenting it.

By first assuming Boyle's law, relationships are set up which, upon being experimentally verified, furnish a proof of its existence. The demonstration is unique in that a complete proof is possible without the knowledge of any of the pressures involved. Furthermore, notwithstanding the fact that an accessory pressure measuring instrument, such as a barometer, is wholly dispensed with, each of the pressures may be definitely determined. Finally, since all quantities are thus known—the volumes by direct measurement and the pressures indirectly—the law becomes applicable in its usual form.

The apparatus, though very simple, is so complete in itself that all the necessary data are secured through the medium of a meter stick. It consists of a capillary tube enclosing, by means of its sealed extremities, a thread of mercury in its central portion and a column of air at each end. The tube should be 110 to 120 cm. long and of uniform bore, 1 to 1½ mm. in diameter. While the lengths of the air columns may be arbitrarily chosen, their ratio is preferably less than 2:1 and greater than 1:1 when the tube is in a horizontal position. The length of the mercury thread is to be governed largely by the pressure with which the air is enclosed. In general, one would choose to have it shorter when this pressure is low than when it is high. In any case, however, there is considerable latitude in the choice depending on the range of values desired. Thus, to anticipate some of the deductions which are to be made in the subsequent analysis, when the air is sealed in at a pressure of 60 cm. and the mercury thread is neither very much longer or shorter, a series of ratios between the volumes of one of the air columns from 1:1 to 2:1 or 3:1 may be obtained, but when the initial pressure is 40 cm. a ratio up to 4:1 is possible. The range may be indefinitely increased by using longer mercury threads, thus making smaller and smaller the initial volumes, but this must not be carried too far if the results are to be reliable, since the errors in the measurements then become proportionately larger.

An experiment is made by first placing the tube in a horizontal

position. The lengths of the air columns are measured and these being proportional to the volumes are designated as V_1 and V_2. The pressure is the same for both: let it be P. The tube is then arranged vertically, or at any angle, say with the end previously designated as V_1 downward. The new volumes are determined as before; let them be v_1 and v_2 and the corresponding pressures, p_1 and p_2. The tube is next inverted or made to assume a position which we may term the conjugate of the first, *i. e.*, it has the same inclination but with the ends reversed. The resulting volumes and pressures become respectively, v'_1 and v'_2, p'_1 and p'_2. Let the vertical component of the mercury thread be h. (See diagrams.)



One set of observations such as above indicated will furnish the data necessary for the establishment of Boyle's law. The analytical expression in which they are to be employed is derived as follows: We first assume the law, writing

$$PV_1 = p_1v_1 = p'_1v'_1 \qquad (1)$$

$$PV_2 = p_2v_2 = p'_2v'_2 \qquad (2)$$

which relationships taken together with the obvious ones that

$$p_1 = p_2 + h \qquad (3)$$

$$p'_1 = p'_2 - h \qquad (4)$$

and

$$V_1+V_2 = v_1+v_2 = v'_1+v'_2 \tag{5}$$

will furnish the basis of all the subsequent analysis.

From (1) and (2) it follows that

$$P(V_1+V_2) = p_1v_1+p_2v_2 \tag{6}$$

$$= p'_1v'_1+p'_2v'_2 \tag{7}$$

With substitutions from (3) and (5), (6) becomes

$$(P-p_2)(v_1+v_2) = hv_1 \tag{8}$$

Similarly, (7) may be rewritten

$$(p'_2-P)(v_1+v_2) = hv'_1 \tag{9}$$

Dividing (8) by (9), substituting for p_2 and p'_2 from (2) and rearranging give

$$\frac{v_1v_2}{v'_1v'_2} = \frac{v_2-V_2}{V_2-v'_2} = \frac{V_1-v_1}{v'_1-V_1} \tag{10}$$

(The equivalence of the right hand members of (10) follows from (5).) This equation is general in that it expresses a relationship which exists between the volumes for *any* pair of conjugate positions. It will be observed that the numerator and denominator of the right hand members are simply the *changes* in volume which *either* air column undergoes when the tube initially horizontal takes respectively each of two conjugate positions. Thus we are permitted to state.—When the tube, originally horizontal, assumes successively each of any two conjugate positions, the attendant *changes* in volume bear the same ratio to each other as do the *products* of the *pairs* of volumes. The identities resulting from the substitution of the observed values for each of the various volumes in (10) establish Boyle's law as rigorously as may be desired.

To apply the law in its usual form, it is necessary to determine the values of each of the pressures involved. Any of these may be obtained independently of the others, in terms of the vertical component of the mercury thread from such data as we have already considered. It will be sufficient to set up the analytical expressions for each of the pressures involved in a conjugate arrangement.

We have from (3), (1), and (2),—

$$p_1 = p_2+h = \frac{PV_2}{v_2}+h = p_1\frac{v_1V_2}{V_1v_2}+h = h\cdot\frac{V_1v_2}{V_1v_2-v_1V_2}$$

With the aid of (5) this reduces to

$$p_1 = h \cdot \frac{V_1}{V_1+V_2} \cdot \frac{v_2}{\underset{(V_1-v_1)}{v_2-V_2}} \tag{11}$$[1]

(The denominator of the right hand factor may take either of two forms as a consequence of (5). This is indicated by writing the alternate form in parenthesis beneath the one to be preferred. It will be convenient to have further recourse to this device.)

Similarly, we obtain

$$p_2 = h \cdot \frac{V_2}{V_1+V_2} \cdot \frac{v_1}{\underset{(v_2-V_2)}{V_1-v_1}} \tag{12}$$

$$p'_1 = h \cdot \frac{V_1}{V_1+V_2} \cdot \frac{v'_2}{\underset{(v'_1-V_1)}{V_2-v'_2}} \tag{13}$$

$$p'_2 = h \cdot \frac{V_2}{V_1+V_2} \cdot \frac{v'_1}{\underset{(V_2-v'_2)}{v'_1-V_1}} \tag{14}$$

To determine P the above values are substituted in (1) and (2). Thus

$$P = \frac{p_1 v_1}{V_1} = \frac{p_2 v_2}{V_2} = \frac{h}{V_1+V_2} \cdot \frac{v_1 v_2}{\underset{(v_2-V_2)}{V_1-v_1}} \tag{15}$$

$$= \frac{p'_1 v'_1}{V_1} = \frac{p'_2 v'_2}{V_2} = \frac{h}{V_1+V_2} \cdot \frac{v_1' v'_2}{\underset{(V_2-v'_2)}{v'_1-V_1}} \tag{16}$$

The foregoing expressions show that the pressure associated with any particular volume may be definitely determined and that a series of such associated pressures and volumes leads at once to Boyle's law in its familiar form. The calculations become simplified and the necessary observations for each case are reduced in number when it is noted that V_1 and V_2 are each constant, regardless of temperature, and so may be determined once for all.

An inspection of (15) and (16) reveals the fact that since P is *constant* for a given temperature, and can be calculated from observations made for any one position of the tube, a more general relationship than that in (10) has been set up. This relationship with the underlying conditions may be fully set forth in the comprehensive statement that, when a long capillary tube,

[1] $(V_1+V_2)(v_2-V_2) = V_1(v_2-V_2)+V_2(V_1-v_1) = V_1 v_2 - v_1 V_2$

enclosing two columns of air separated by a thread of mercury, is tilted from a horizontal position to *any* other, the *change* in volume which each column undergoes is proportional to the product of the resulting *difference* in pressure and *each* of the pair of resulting *volumes.*

All the above relationships have been verified by experiment with an approach to exactness fully equal to that obtainable with any of the common devices employed in the demonstration of Boyle's law. While this method is, in a sense, indirect, the consequent instructive nature of the analysis together with the simplicity of the apparatus and its manipulation are such attractive features as to recommend a place for this device in the laboratory where it may be accessible to pupils.

This demonstration might well terminate at this point, but to those who are not inclined to shun algebraic manipulations it may be of interest to see them extended further so as to express the quantities considered above in other forms.

All the pressures may be expressed in terms not involving V_1 and V_2, as follows,—

From equations (3) and (4) we have

$$p_1+p'_1 = p_2+p'_2 .$$

which becomes after making substitutions from (1), (2), and (3), and rearranging

$$p_1 = h \cdot \frac{v'_1(v_2+v'_2)}{v'_1 v_2 - v_1 v'_2}$$

or with the aid of (5)

$$p_1 = h \cdot \frac{v'_1}{v_1+v_2} \cdot \frac{v_2+v'_2}{v_2-v'_2} \qquad (17)$$
$$(v'_1-v_1)$$

In like manner,

$$p_2 = h \cdot \frac{v'_2}{v_1+v_2} \cdot \frac{v_1+v'_1}{v'_1-v_1} \qquad (18)$$
$$(v_2-v'_2)$$

$$p'_1 = h \cdot \frac{v_1}{v_1+v_2} \cdot \frac{v_2+v'_2}{v_2-v'_2} \qquad (19)$$
$$(v'_1-v)$$

$$p'_2 = h \cdot \frac{v_2}{v_1+v_2} \cdot \frac{v_1+v'_1}{v'_1-v_1} \qquad (20)$$
$$(v_2-v'_2)$$

To set up a similar expression for P, the values of V_1 and V_2 as obtained from (10) are substituted in any one of the equations (15) and (16)

$$P = \frac{h}{v_1+v_2} \cdot \frac{v_1v_2+v'_1v'_2}{v'_1-v_1} \qquad (21)$$

$$(v_2-v'_2)$$

Equations (17)-(21) are similar in form to (11)-(16). The relationships are not greatly modified. (21), like (15), is general, and interpreting it, we see that the *change* in volume which either of the air columns undergoes when the tube assumes successively each of two conjugate positions is proportional to the product of the *difference* in pressure and the *sum* of the *products* of the associated pairs of volumes.

Again, since P is essentially constant, all other pressures may be obtained by adding to, or subtracting from, it, and such analytical expressions follow. From (11) and (15) we have

$$p_1 = P + \frac{1}{V_1+V_2} . hv_2 \qquad (22)$$

Similarly

$$p_2 = P - \frac{1}{V_1+V_2} . hv_1 \qquad (23)$$

$$p'_1 = P - \frac{1}{V_1+V_2} . hv'_2 \qquad (24)$$

$$p'_2 = P + \frac{1}{V_1+V_2} . hv'_1 \qquad (25)$$

AN INDUCTION APPARATUS.[1]

By C. F. Adams,
Detroit Central High School.

This apparatus is used for so many different purposes that it is difficult to give it a suitable name. Mr. Randall of Pratt Institute has named it a Model Dynamo, and in my textbook I have called it "Apparatus M." It is not intended for a laboratory piece but for the lecture table. Its design is so simple and all electrical connections are so apparent to the student as it stands before him in the lecture room that almost no explanations are necessary on the part of the teacher. This is perhaps its most valuable feature; but makers of apparatus have at various times suggested mechanical improvements which invariably sacrifice this simplicity and visibility of connections. So many questions have been asked in regard to it since its exhibition at the Central Association meeting that it is described here in detail. It consists in the main of a stand and three coils.

The stand consists of a base board 18"x5½"x⅞" (Fig. 1) and four uprights, each 16"x2"x½", secured to the base by screws up through the base. The two inner uprights are 10" apart. The brass bar A across the top is 7/16" square and the brass bar B fixed to the base is 5"x⅝"x¼" and has a small cavity in at *o* which is filled with mercury. A ½" hole is bored through the base near *o* to permit the removal of a coil from the stand by dropping the rod *c* down through the hole so as to disengage the rod *d* from the bar A. A ⅛" hole extends vertically through A at its center and two milled head 8-32 thread screws pass through A horizontally two inches from the center on either side. Binding posts are attached to both A and B. The uprights are slotted to hold magnets as shown in Figure 3. These magnets are 9"x¾"x⅜". In addition some sort of support is needed for the coil No. 3. One method of support is shown in Figure 2.

The Coils.—Coil No. 1 is shown in position in Figure 1. It consists of a very light frame 10½"x4"x1". The sides of the frame are wood and the ends of aluminum 1/16" thick (Fig. 6). The axles *c* and *d* are brass rods having an 8-32 thread cut upon them. They are fastened to the frame by being screwed through the aluminum plates and secured by lock nuts on either side of the plate. An iron cup (made of a roller skate wheel) is screwed

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[1]Read before the Physics section of the Evanston, Ill. Meeting of the C. A. of S. and M. T., Nov. 29, 1912.

upon the rod *d* and the upper end of *d* is turned down to fit loosely the hole in A. The lower end of *c* is turned down to a smooth rounded polished point. The frame is wound with 50 or 60 turns of No. 20 magnet wire the ends of which are soldered to the rods *c* and *d* in such a manner as to be plainly visible at a distance. To avoid short circuits cover the corners of the frame and the rods with cloth saturated with shellac and if the wire is saturated with thick shellac it need not be bound to the frame. An L shaped piece of brass (Fig. 4) held to the rod A by one of the milled head screws dips into the mercury in cup *i*. The end of L and the lower end of *c* are amalgamated and the upper end of *c* is pointed for the purpose of supporting a magnetic needle.

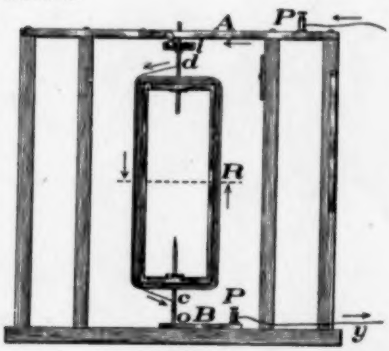

FIG. 1.

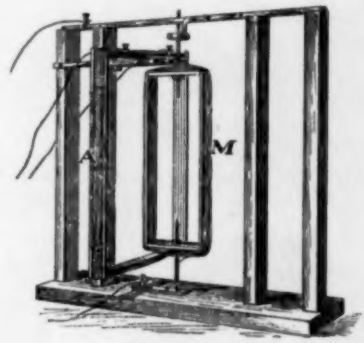

FIG. 2.

Coil No. 2, $10\frac{1}{2}''$x$5''$x$1''$, is similar to No. 1, but it has a two part commutator in place of the iron cup as shown in Figure 3. The commutator is made of a rod of fiber $\frac{1}{2}''$ in diameter covered with two half cylinders cut from thick brass tubing. They are fastened to the fiber with small screws. The commutator is tapped with an 8-32 thread and screwed upon rod *d*, the ends of the wire being soldered to the two halves.

Coil No. 3 shown at A (Fig. 2) has a frame $13\frac{1}{2}''$x$8\frac{1}{2}''$ and is wound with wire like No. 1, the ends of the wire being attached to binding posts on one side of the frame. This coil is to be held in the hand or supported in different positions near the other coils. Two diagonally opposite corners of all coils are painted red to enable one to keep in mind the direction of the current in a coil after it is once determined. A small arrow of wood or brass is attached to the side of each coil so that it can be turned to indicate the direction of the lines of force through the coil after it is determined.

Figure 5 shows one of the brush holders which are shown in position in Figure 3. It consists of a block of fiber $2\frac{1}{2}''$x$1\frac{1}{2}''$x$\frac{1}{4}''$ having a square groove to fit rod A (Fig. 1). They are held in place by the milled head screws through the slot *s*. The brush is a thin strip of brass or copper.

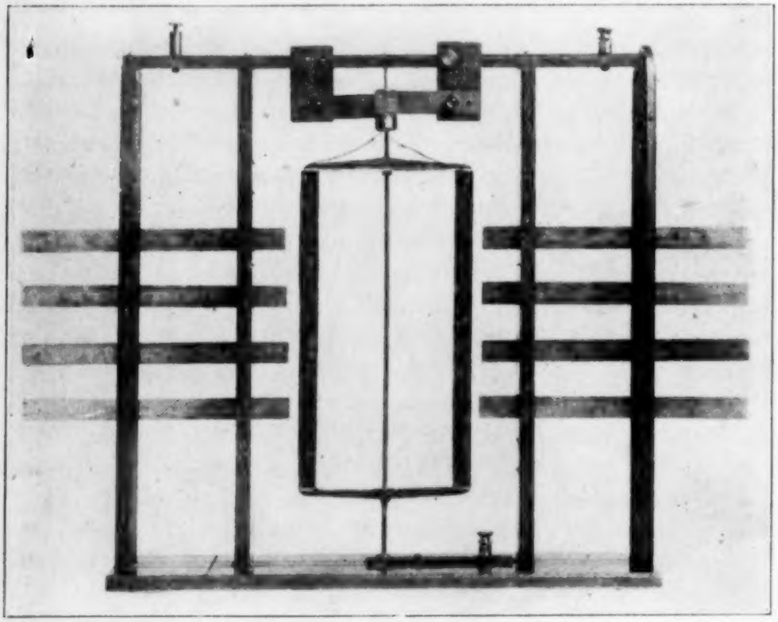

FIG. 3.

Figure 7 represents a watch spring. The outer end of the spring is soldered to a brass pin P and the inner end to R. A hole through R is of such size that it fits snugly upon the upper end of rod *d* of coil No. 1. The pin P fits a vertical hole through A one inch from *d*. This spring is used to bring the coil back to zero position acting in the same manner as a similar spring in a Weston voltmeter.

The coils here described are suitable for use with dry cells or storage cells and need about 10 volts P. D. For a 110 volt circuit I have used a set of coils having about 225 turns of No. 26 wire, using them in connection with a rheostat. For the induction experiments when the coil is connected with a sensitive galvanometer the 225 turn coil gives better results. It is an advantage to have two No. 1 coils one of fine wire and one of coarse wire.

Uses of the Apparatus.

First with coil No. 1 in the stand:

(1) The coil is a magnet. If the point of *c* is smooth also the bottom of the cavity *o*, with a strong current the coil will turn to face north and south by the earth's attraction.

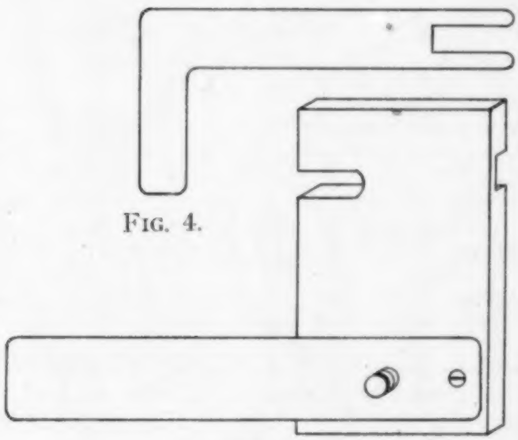

Fig. 4.

Fig. 5.

Fig. 6.

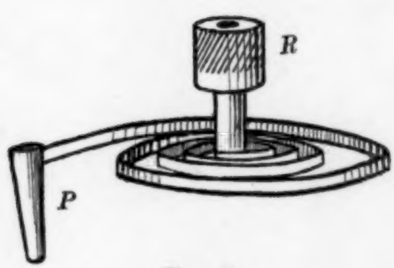

Fig. 7.

(2) The coil is a magnet. Shown by presenting the pole of a bar magnet to it; it will behave toward the bar magnet like a magnetic needle.

(3) The field of the coil. Two pieces of cardboard are cut to fit closely about the coil in a horizontal plane along the dotted line (Fig. 1). Saw cuts in the uprights support the cardboard. Map the field of the coil with filings and determine direction of lines of force with compass. This field is very important.

(4) Study deflection by placing needle on rod *c*.

(5) Connect Coil No. 3 to a battery. (It may be in series or parallel with No. 1 or independent of it.) Show attraction and repulsion of parallel currents by holding side of No. 3 near side of No. 1.

(6) Place coils as shown in Fig. 2. Action of angular currents is shown.

(7) Relation of fields or lines of force of the coils can be studied.

(8) Principle of electric dynamometer illustrated.

(9) Attach the watch spring to No. 1 also a wooden pointer or a small mirror. Place the magnets in the stand as shown (Fig. 3) and illustrate the D'Arsonval galvanometer. Use a single dry cell.

(10) Remove the spring and join the coil to a sensitive galvanometer. Illustrate induction by turning coil in the magnetic field.

(11) Study direction of induced currents.

(12) Set coil in rotation. For this purpose use a pin like R (Fig. 7). This illustrates alternating currents. Shown by the vibration of the galvanometer coil.

(13) The magneto is illustrated.

(14) With a fine wire coil and a very sensitive galvanometer the earth's field will give induced currents, although the lines of force thread the coil very obliquely.

(15) The mercury in *i* and *o* illustrates the use of collecting rings.

(16) Remove coil No. 1 and place No. 2 in stand and attach the brushes. Connect to galvanometer. Rotate the coil and obtain direct current.

(17) Explain commutator.

(18) Explain brushes.

(19) Disconnect galvanometer and join to battery. A direct current motor is formed.

(20) Remove magnets from stand and place coil No. 3 as shown in Figure 2. It may then be run either as a series or shunt D. C. motor.

(21) Induction experiments may be repeated with coil No. 3 instead of magnets furnishing field. Dynamo illustrated.

(22) With an alternating current and coils 2 and 3 it may be run as an A. C. series motor.

(23) Mr. Randall has added an attachment to the coil to arrest its motion at different points in its revolution ot study the induction quantitatively and to obtain the sine curve.

A NEW LIST OF TOPOGRAPHIC MAPS FOR USE IN HIGH SCHOOLS.

By W. H. Norton,

Professor of Geology, Cornell College, Iowa.

At the November meeting of the Iowa State Teachers' Association, a committee appointed to stimulate, if not to standardize, the laboratory teaching of Physical Geography in Iowa high schools made a report which may be of interest to teachers outside of the state. In the division of the work of the committee, which consisted of Professor E. J. Cable of the Iowa State Teachers' College and myself, there fell to me the subject of land forms and the task of preparing a list of topographic maps for high-school use.

A laboratory manual—and several excellent manuals were shown and recommended at the session,—is doubtless a necessity

for teachers untrained and inexperienced in the use of topographic maps. Others may prefer to give their class work a more individual shaping, and to any such the Iowa list may prove helpful.

The list is a short one, it comprises but forty maps; since the thorough study of a few maps is better for the high school pupil than a cursory comparison of many. The selection of this small number out of the hundreds published by the U. S. Geological Survey was by no means easy. Maps for school use must present typically, plainly, and vividly the land forms for which they are selected.

In most of the maps of the list the main features are set forth so graphically that they may be read even across the school room. Preference is given to sheets which illustrate physiographic provinces or noted localities, which afford historic and economic correlations, which are readily placed by the pupil, and which permit such exercises as forecasts of future stages and restorations of past stages of the erosion cycle.

Although the later maps of the Survey are on the whole better done than the earlier, some of the quadrangles listed are those of early publication and of long and wide use in schools. No better example of the young lacustrine plain has yet appeared than the Fargo, N. D., quadrangle. The Portage, Wisconsin, sheet is suggested for a young area of glacial drift, since it presents the very early stage of the river channel not yet sunk below the level of its feeding swamp-lands, a divided valley, and a portage of historic interest and one which lends itself to problems of the future of the two competing rivers, the Fox and the Wisconsin, under conditions either of aggradation or of degradation.

For an area in early maturity the Coharie, N. C., sheet is selected because it shows so distinctly an advance upon the Fargo area, both in growth of tributaries and in development of the valley of the master stream, while the interfluves preserve much of the initial plain. The quadrangle is typical of the middle portions of the Atlantic coastal plain, but not entirely of the lower marginal portions as seen in the Newbern and Trent river (N. C.) quadrangles, which may well be used for comparison.

For topographic maturity the Arnoldsburg, W. Va., sheet has a pictorial quality unsurpassed. Other later maps of the Appalachian plateau show deeper, though not more intimate, dissection and some, as the Pocahontas, W. Va., special, may be preferred for the concentration of mining population in the valleys.

For Iowa schools the Waukon, Iowa, quadrangle may be sufficient for this stage of the cycle, since it shows a complete dissection of an unlifted peneplain. It also shows the braided channels of the upper Mississippi river, river terraces, and the advanced development of incised meanders in the Upper Iowa Valley.

Under the development of valleys, the Kansas City, Mo., sheet shows a bluff-bound stream whose flattened meanders are actively engaged in planation; the Elk Point, Iowa, sheet an advanced stage of flood plain and the deflection of tributaries by natural levees; while the Patoka, Ind., sheet remains the best example of an old-age valley, with monadnocks and a topography post-mature. Under cycles of erosion, the Harrisburg, Pa., sheet remains indispensable, but it may well be supplemented by a western example, such as the Ft. Collins, Colo., quadrangle with its graphic presentation of the uplifted peneplain of the Front Range of the Rockies, hogbacks, the peneplain of the margin of the great plains which here truncates tilted strata, and lake basins attributable to deflation.

A new feature of the list is the prominence given to the Arid Cycle. The Corazon, N. M., sheet exemplifies the *hamada,* or plateau rock-desert, with marching cliffs, rincons, mesas at different levels, and blind-end valleys. Desert mountains with aiguilles of Alpine sharpness, waste slopes furrowed by arroyos and the Gila river wadi are finely set forth in the Sacaton, Ariz., quadrangle, while the Van Horne, Tex., sheet adds an excellent bolson and a salt lake basin.

The dune landscape is seen in the Camp Clark, Nebr., sheet, chosen because it presents two sources for dune sands,—the river flood-plain and the country rock. The Cucamonga sheet remains the best example of the bajada, or piedmont waste slope, and illustrates also the utilization of ground water, the principle of the ciénaga and the distribution of population.

Under montanic glaciation Chief Mountain sheet, Mont., alone would almost suffice, with its glacierets, cirques, comb-ridges, and sharpened peaks, its glacier troughs, pater-noster lakes and elongate lakes or *Chelans* as they might well be called. But for further example, I have added the Leadville, Colo., quadrangle, especially because of the glacier trough of the Lake Creek gulch, with its hanging valleys and the Twin Lakes held by its terminal moraines, and the Hayden Peak, Utah, quadrangle for its magnificent clustered cirques and combs.

Under continental glaciation, a new departure may be noted in the illustration of the topographies of successive drift-sheets. The early-mature surface of the Kansan drift sheet is shown in the Knoxville, Iowa, quadrangle of this year's issue, the markedly less dissected Illinoian drift plain in the Tallula, Ill., quadrangle, the Iowan drift sheet in strong contrast with driftless area topography veneered with Kansan drift in the Oelwein, Iowa, quadrangle, and (especially for Iowa students) the Des Moines sheet for the Wisconsin and Kansas drift sheets. The morainic topography of the Wisconsin is shown on the St. Paul, Minn., sheet along with most interesting drainage modifications.

Lineaments, which have received little or no attention in our manuals, are exemplified in the San Andreas rift, chosen because of its unmistakeableness, and also because of the fact that the great California earthquake of 1906 was due to the latest dislocation along this fault plane. It is shown in two sheets, the Tamalpais and the San Mateo, Calif., both of which may well be obtained since they illustrate shore forms also.

Topographic youth.	
Lacustrine plain	Fargo, N. D.
Wisconsin drift	Portage, Wis.
Adolescence	Coharie, N. C.
Maturity	Arnoldsburg, W. Va., or Waukon, Iowa.
Development of valleys	Niagara, N. Y.
	Canyon, Wyo.
	[1]Bright Angel, Ariz.
	Kansas City, Kan. and Mo.
	Elk Point, Iowa, S. D. and Neb.
	Patoka, Ind. and Ill.
Stream Capture	Kaaterskill, N. Y.
Cycles of erosion.	Harrisburg, Penn.
	Ft. Collins, Colo.
Ground Water	Standing Stone, Tenn.
Arid Cycle	
Dune landscape	Camp Clark, Neb.
Rock desert	Corazon, N. M.
Desert Mountains and wadi	Sacaton, Ariz.
Bolson	Van Horne, Tex.
Piedmont waste-slope	Cucamonga, Cal.
Montanic Glaciation	Chief Mountain, Mont.
	Leadville, Colo.
	Hayden Peak, Utah.
Continental Glaciation.	
Kansan drift sheet	Knoxville, Iowa.
Illinoian drift sheet	Tallulah, Ill.
Iowan drift sheet (and Kansan)	Oelwein, Iowa.
Wisconsin drift sheet (and Kansan)	Des Moines, Iowa.
Moraines and drainage modifications	St. Paul, Minn.
Drumlins	Weedsport, N. Y.

Lineaments	Tamalpais and San Mateo, Cal., sheets.
Volcanism	Mt. Shasta, Cal., special. Crater Lake, Ore. Mt. Taylor, N. M.
Shoreforms	
Shores of Submergence	Boothbay, Maine. Boston Bay, Mass. Martha's Vineyard, Mass. Provincetown and Wellfleet, Mass.
Shores of Emergence	Oceanside, Cal. Atlantic City, N. J.

[1]These maps can be obtained from the Director U. S. Geological Survey, Washington, D. C., at a cost of six cents each (starred maps twelve cents) when the order amounts to $8.00 or more. The cost of ten copies of each of the forty maps is thus $24.60.

PRACTICAL BIOLOGY.

By George C. Wood,

Instructor in Biology, Boys' High School, Brooklyn, N. Y.

It is not the purpose of this article to defend or justify the position of Biology in the curriculum of the secondary school. The necessity of such a procedure has passed. The practical applications of a great majority of the experiences gained in the study of living forms have firmly entrenched the subject within the confines of the "practical and cultural" studies. It appeals to the needs of the "masses" as well as the "classes" and it has come to stay.

Biology is a newcomer among us, and yet it is old. It began with Aristotle. With him, as with us of the last decade, it was and is a study of *life*. And here is the first bone of contention between the true student and patron of Biology and the semi-modern critic of Biology. These critics remember with unpleasantness, their "experiences" in the study of "Biology." They studied frogs, seeds, eggs, flowers, and multitudinous "Structures." To-day, we study—*life*. Life is studied as a great principle and frogs, seeds, flowers, etc., are observed as beautiful variations of the manifestation of that principle. Life is the same phenomenon, enshrouded in a substance called protoplasm—whether found in an Amoeba, toad, tree, orchid, elephant or man. Under the influence of the great *Urkraft* (force), as the Germans call it, within or behind it, there is bound to be an expression of its essential character in forms as various and as many as the sands of the sea shore. With this understanding as to the fundamental principle of Biology what a different front it should

present than the one so commonly ascribed to it—the "inexact," "indefinite," "superficial," "dry" subject.

In 1500 the real study of Biology began. It, however, was *not* a study of life, but rather of structure. The Biologist did not see the ***principle*** behind the *form*. Through the long maze of investigators—Malphigi, Leeunwenhoeck, Bock, Saochs, Linnaeus, Buffon, Cuvier, Goethe—the flame of life flickered on. It remained for Darwin to fan this flame into a conflagration, by the publishing of the greatest book of the Nineteenth Century. He attempted to explain the ***principle*** behind the form. With the great weight of approval of such men as Huxley and Spencer, the stamp of content and solidarity was given the theory of natural selection. There was seen a close connection between "Science and Education." To educate in science was a problem put up to the "evolutionist." Nothing then being known of the practical bearings of the subject in its relation to human life and organized society, the educators fell back upon that phase of the subject with which they were best acquainted—the theory of evolution—a theory which had become a part of their very bone and fibre. The result was the ludicrous and at the same time pathetic college biology in the first year of the high school course within the teaching memory of most of us. The excuse for this heart-rending procedure was that the study of structure was of great "disciplinary" value. What a boy gained by the study of the number of legs on a crayfish was "carried over" and made applicable to any other experience. But what a change has come about! In the first place, the truth of the evolutionary theory as developed and elaborated by Darwin is practically universally accepted. It needs no more advocacy. In the second place, Pasteur, Metchnikoff, Ehrlich, Lister, Flexner, Carrell and others have shown the human and vital side of Biology to an extent almost beyond the powers of comprehension of the ordinary observer. In the third place, Thorndyke and others have shown that "formal discipline" does not do all that is claimed for it,—that because a boy can accurately observe and draw the mouth parts of a honey bee, it does not follow that he can the better distinguish good eggs from bad, or see more things in a shop window after a casual glance than before. In other words, a matured "scientist" cannot be made from a grammer school "prodigy" in one or even two years, and we can prove it. We now feel that the teaching of structure is not the chief desideratum in the high school course of Biology.

If we can get the youth to feel the significance of life with its progress and expression and its relation to man, we are accomplishing our task in education as far as Biology is concerned.

So Biology has been gradually changing front during the last five years. This change has been from the *structural* attitude to the *functional* attitude. There were two reasons for this. First, biology in connection with its applications of evolution caused an evolution in every other subject in tthe curriculum. It permeated our very processes of thought. But biology refused to take its own medicine. It refused to be evolved. In consequence, there came a flanking movement and it was obliged to change front or be defeated and ousted root and branch from our secondary school curriculum. Second, many practical men saw that there was just as much disciplinary value in observing and drawing conclusions in connection with familiar and useful life forms as with those unfamiliar and useless. Experimentation disclosed the practical, vital, cultural, informational and *interesting* side of Biology, which had long been obscured. The enemies of secondary biology thought these things non-existent in connection with it; its friends had a strong suspicion that they were there, but couldn't diagnose their location.

We teachers of biology (that is, some of us at least) have come to realize that more than one-half of all the phenomena that come under human observation are related to the biological sciences. Much of our unconscious life has to do with the science of life. Our instinctive desire to fulfill the great needs of living things as, for example, the getting of food, oxygen, clothing, shelter, or in satisfying the desire to work or play. All these are fundamentally biological.

Physiology, etyology, comparative anatomy, histology, paleontology, medicine and even psychology are indissolubly linked with biology.

In our cities, towns, and country, the sanitation, plumbing, sewage, street cleaning and heating and lighting are all biological considerations. Ordinances controlling diseases, building laws, factory and tenement house laws are based on bacteriology.

In our business life applied botany and zoölogy are conspicuous. Cattle raising, dairy products, meat packing, sheep and wool industries, stock breeding, fisheries, all involve biological principles.

In the breeding and improvement of cotton, wheat, rye, corn and many other cereals we find the fundamentals of life.

In the work of Burbank and Webber and Davenport and Galton, we have the applications of the laws of plant, animal and human life to breeding and eugenics—all biological in nature.

The subject of sex hygiene is monumental in its importance to the future of America. We speak of gambling and drink evils. Crusades are waged against them, but nothing is said about sex knowledge and hygiene, except in certain enlightened and progressive centers. The gambling and drink habits are not to be mentioned in the same day with the enormity of our social evil in its effect upon the vitality and happiness of the race. Our social order is becoming honeycombed with venereal infection. According to Dr. Prince Morrow of the Society of Moral and Social Prophylaxis, 200,000 persons walk the streets of New York City loaded with venereal diseases. To stem this tide of disaster is the work of the preacher, the physician and the parent—materially aided by the teacher of Biology.

The city of Chicago has instituted fifty centers for the instruction of parents in matters of sex. This is timely and practical. In New York City such a step is being contemplated by the educational authorities.

These last few paragraphs may seem to the reader to be far from the point. They may seem to be an argument for biology as deserving a place in the high school curriculum. But it will be remembered that in the opening paragraph of this article the writer attempted to make clear the fact that biology "had come to stay" because of its recognized vital and practical character. The above, therefore, is but an exposition of the basis for the new teaching of biology and a warning to the old-time teacher that *he must change front or be lost in cast-off ideas of other years.* The future biology must be *cultural* and *civic*. Some of us are tinged with this spirit now. We want more of this spirit in order that our teachings may become more effective.

A subject is what it does. The value of Biology should rest upon its *constructive* value, its *utilitarian* value and its setting of *high ideals*. It begins to fit into the common experiences of the pupil at a much earlier age than almost any other subject in the secondary school curriculum. To put it differently. Let a boy leave school at the end of his first or second year, and he will consciously or unconsciously find that his biological knowledge will be brought into requisition three times where his

algebraic, or physical science or foreign language information will be used once—and I think this is a conservative estimate. The school must be a place of diverging lines of activity; not of converging lines of passivity. The world is calling for those who *can be something* and *can do something.* Here is the opportunity of biology, because it comes into most intimate relation with the needs of the world and can thus do the world's work. Its opportunity does not stop even here. It can be made a source of *service* to the world at large. There are now over forty high schools in New York state where agriculture is made the core of the elective courses in these respective schools. These courses are for those who do not desire or are not fitted to enter professional life, and the Almighty knows that there are more of the latter class than we generally care to admit. The trained agriculturist is as well trained and educated as your Ph. D.'s and your LL. D.'s—if he can do his job. Biology, then is to be congratulated because it is at this moment *helping* many a young man and woman find his or her job in life and because it is *preventing* many a young person from becoming "educated" in the long time accepted sense of the term, because "education" to many spells, *unfitness* for what they once did or what they hoped to be because of inborn incapacity; and dissatisfaction with the world because of the wrong impression that it owes them a living together with the inevitably painful disillusionment.

To accomplish the great services enumerated above, biology should first teach *Honesty,* because it is the basis of all right social intercourse.

Second, It should teach *Health,* the basis of all success because it necessitates a sound body, a sane mind, a long adult life, healthy offspring, financial independence.

Third, it should teach *Consideration,* or respect for the rights of others.

Fourth, it should teach *Co-operation,* the willingness and ability to work with others to accomplish work impossible to one.

Fifth, it should show the meaning and advantage of *Specialization,* a condition necessary for eminent success today.

To explain how biology can do these things would necessitate enough matter for another article, but it may be briefly summarized as follows:

First, you cannot bluff nature by sowing seeds guaranteed to

grow and produce a harvest without care and cultivation. Nature demands honesty because she is honest herself.

Second, you cannot bluff the inexorable laws of health and expect to live long.

Third, you cannot break up the fundamental laws of co-operation, the backbone of the social fabric.

Fourth, you cannot fool facts, though they may fool you, not because they are false, but because you are not discerning. They stand unimpaired regardless of *your* opinions.

Fifth, you cannot stop the industrial and economic development of today based upon specialization. If you are honest, you must fall in line, adopt the principles expressed in the study of the facts and truths of Biology, as the law of your very being. If the student of Biology learns nothing else but the one great truth—that all animal and plant life is absolutely inter-related and inter-dependent, by absolute subservience to natural laws as a prerequisite for the proper development of the individual and the race—this one great truth will give him an outlook upon life for which nothing else will begin to be a proper substitute.

But someone will object to this line of development by saying, "This is not biology, but rather civics." I answer that I will not combat the objection. It may not be biology, pure and simple. It may take on the characteristics of civics. Call it what you may, it is based upon biological principles, which are applicable to the life and conduct of the human animal and that is enough. We are fast coming to realize that we must take things and conditions as we find them, not as we would like them to be. We face the real, not the ideal. But the ideal, socially speaking, is the best possible for the race in the present age under the existing conditions. The biology outlined here meets the needs of the great masses of the people in our larger cities and towns. Therefore it is the best.

We recognize that the conditions in the rural communities are far different and biology can there be studied for its own sake, but even here I would look with suspicion upon the teacher who in a rural section refused to make clear the applications of corn breeding in a practical way, because it was not pure biology.

Now, no one is more aware than the writer, of the ridiculous extent to which "civic" biology can be carried. Some of the recent text books are absolutely absurd. A biologist antagonistic to the new biology, because of what he calls its "dollars and cents" tendency (with which I do not agree) made out a speci-

men laboratory exercise upon the mammals in order to show the absurdity of the applications of this tendency. The exercise began in substance as follows: Locate a cow. Has she a head? tail? how many legs? Does the cow give milk? Visit a modern dairy and observe how much milk the cow gives. How much butter will a gallon of milk make? What is buttermilk? What is it good for? What is cream? What is butter used for? Why is butter high priced? Account for the high cost of living.

Visit a butcher shop. Talk with the butcher on the high cost of meat. Ask him how much he makes on a quarter of beef. Find out from what part of the carcass the different cuts of beef come. Get the prices of each cut and account for the difference in prices. Find out the difference between round, sirloin, porterhouse, and top sirloin and report in class tomorrow, etc.

I claim the above ridiculous in exaggeration and entirely misses the issue. Civic Biology does not attempt nor ought to attempt to enter such an avenue of activity in even the mildest way. If it did it would not be Civic Biology.

Some facts are essential to the proper teaching of Civic or Practical Biology. The pupil should be encouraged to organize his already fairly complete store of common facts into a systematic whole, to be placed where he can use it and make it effective. How this can be done and is being done in our school as far as human endeavor with a chance for improvement, can do it, is outlined in a letter by the writer in *The Outlook* of August 20, 1910.

In the course of study there outlined we stand for the four great fundamental principles of all life: First, Need of Food. Second, Need of Air. Third, Need of Protection for the Individual. Fourth, Need of Reproduction for the Race. And there is not a single mass of protoplasm, but that seeks to fulfill all of these four great needs. Structural study to a limited extent in order to fully understand function follows naturally and the economic importance of the form studied is, of course, emphasized, because that makes it vital. To summarize the content of the three phases or divisions of the subject of biology as taught in our school, it will suffice to add the following: Plant Biology attempts to develop the great needs and principles of living things. Animal Biology attempts to elaborate and apply these principles to the higher animal forms. Human Biology attempts to apply the principles and needs of living things to the human mechanism with a view to its proper conservation by proper habits of hygiene.

The supreme *goal*, then, of all first year biology teaching should be, under present conditions, the *conservation* of the *individual* and his preparation for *service*.

The results of such teaching are not commercialized. The supreme *result*, with due consideration for the cultural value of the subject, is the conservation and well being, and complete enjoyment and happiness of the individual and of the race.

In its broader aspects, such biology teaching does and will accomplish the following things:

First, it will give practical and cultural and not technical training in the immature years.

Second, it will instill ideas and ideals to aid the growing boy and girl to attain a wider outlook and larger life.

Third, it will promote ideas of honesty, health, consideration, co-operation, etc.

Fourth, it will develop the mental constructive ability of the pupil who will rely upon his apperception primarily and not upon his memory as such.

Fifth, it will teach only those things worth while.

Sixth, it will seek for breadth rather than depth in the treatment of life principles.

Seventh, it will treat of life as it now is, together with its possibilities of improvement in all living forms.

Eighth, it will attempt to make the student, first, a good, wholesome animal, and, second, a good and useful citizen, because he sees himself a real factor as a necessary part of honest and sincere co-operation in the betterment of society—and of the race.

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

318. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

A man was born in the nineteenth century.
He was x years of age in year x^2.
Find his age in the year 1875.

I. *Solution by Levi S. Shively, Mount Morris, Ill., and John M. Gallagher, Boston, Mass.*

Let a be the year in which he was born. Then the conditions of the problem are expressed by the equation

$$x^2-x-a=0, \tag{1}$$

where a is an integer satisfying

$$1800<a<1876. \tag{2}$$

Let m and $-n$ be the roots of equation (1).
Then $mn=a$ (3) and $m-n=1$ (4).

Evidently $\quad m>\sqrt{a}>\sqrt{1800}>42,$
and $\quad n<\sqrt{a}<\sqrt{1876}<44.$
Then either $\quad m=43$ and $n=42$ (by equation 4),
or $\quad m=44$ and $n=43.$

The first set of values is consistent with (2) and (3).
Therefore $a=1806$ and the man was 69 years old in 1875.

II. *Solution by A. H. Hughey, El Paso, Texas, and H. C. McMillin, Lawrence, Kan.*

By the conditions of the problem.

$$1800<x^2-x<1875.$$
$$\therefore\ 1+\sqrt{7201}<2x<1+\sqrt{7501},$$
$$\text{or } 42.926<x<43.801. \quad \therefore x=43.$$

A person who was 43 years old in 1849 was born in 1806 and was 69 years old in 1875.

319. *Proposed by E. B. Escott, Ann Arbor, Mich.*

Solve:

$$x^2-(y-z)^2=a. \tag{1}$$
$$y^2-(z-x)^2=b. \tag{2}$$
$$z^2-(x-y)^2=c. \tag{3}$$

Solution by R. H. Mathews, Riverside, Cal.

Place $\quad u=x-y+z, \quad v=x+y-z, \quad w=-x+y+z.$

Then

$$\left.\begin{aligned} uv&=a\\ vw&=b\\ wu&=c\end{aligned}\right\}\text{(A)}$$

Case 1. Neither a nor b nor c is zero, implies u, v, w each different from zero. Then

$$u = \pm \frac{1}{b} \sqrt{abc}, \quad v = \pm \frac{1}{c} \sqrt{abc}, \quad w = \pm \frac{1}{a} \sqrt{abc},$$

where comparison with (A) shows all signs plus or all signs minus. Solving, we have

$$x = \pm \frac{\sqrt{abc}}{2bc}(b+c), \quad y = \pm \frac{\sqrt{abc}}{2ac}(a+c), \quad z = \pm \frac{\sqrt{abc}}{2ab}(a+b).$$

Case 2. Let $a = 0$, then $u = 0$, or $v = 0$.

$u = 0$ implies $c = 0$.

Then

$$x-y+z = 0,$$

which with

$$y^2-(z-x)^2 = b$$

gives

$$z = \frac{b}{4x},$$

$$y = \frac{4x^2+b}{4x},$$

x arbitrary but $\neq 0$.

$v = 0$ implies $b = 0$.

Then

$$x+y-z = 0,$$

which with

$$z^2-(x-y)^2 = c$$

gives

$$y = \frac{c}{4x},$$

$$z = \frac{4x^2+c}{4x},$$

x arbitrary but $\neq 0$.

In case $w = 0$,

then

$$z = \frac{a}{4y},$$

$$x = \frac{4y^2+a}{4y},$$

y arbitrary but $\neq 0$.

Geometry.

320. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

The distance between the centers of two circles is 15. The length of the common external tangent is 12 and that of the common internal tangent is 10. Required the radii of the circles.

I. *Solution by H. E. Trefethen, Waterville, Maine.*

Let R, r be the radii; O, o the centers; Kk = 12 (Oo = 15), Ff = 10, the given tangents; I their intersection; and Ho parallel to Kk. Then

FI = 11, being the arithmetic mean of Kk and Ff.

R : I = 11 : r, Rr = 11, in the similar triangles OKI and Iko.

$(R-r)^2 = 225-144$, $R-r = 9$, in right triangle OHo.

Whence $R = (5\sqrt{5}+9)/2$ and $r = (5\sqrt{5}-9)/2$.

II. *Solution by I. L. Winckler, Cleveland, Ohio, and A. Babbitt, State College, Pa.*

Let A and B be the centers; CD the common external tangent, tangent to circle with center A at C, and tangent to circle with center B at D; and let GF be the common internal tangent, touching circle with center A at G and circle with center B at F.

Draw AE parallel to CD meeting BD at E and draw AH parallel to GF meeting BF produced at F.

Let $BD = R$, $AC = r$, $R>r$.

Then $BE = R-r$, $AE = 12$, $AB = 15$.

$\overline{BE}^2 = \overline{AB}^2-\overline{AE}^2$ or $(R-r)^2 = 225-144 = 81$.

$\therefore R-r = 9$. (1)

Also $BH = R+r$, $AH = 10$, $AB = 15$.

$\overline{BH}^2 = \overline{AB}^2-\overline{AH}^2$, or $(R+r)^2 = 225-100 = 125$.

$\therefore R+r = 5\sqrt{5}$. (2)

From (1) and (2) $R = \dfrac{9+5\sqrt{5}}{2}$, $r = \dfrac{5\sqrt{5}-9}{2}$

321. *Proposed by L. L. Harding, Suffield Conn.*

The arc of a circle is 350 feet long; the distance from its mid-point to its chord is four inches. What is the length of the chord?

I. *Solution by R. M. Mathews, Riverside, California.*

Let $AM = a =$ the half arc, $AN = c =$ the half chord, $NM = d$. If MT be tangent at M and AT at A, then $MT = AT = x$.

$$\text{Now} \quad c+d>a \qquad \therefore c>a-d \qquad (1)$$
$$c^2+d^2<a^2 \qquad \therefore c<\sqrt{a^2-d^2} \qquad (2)$$
$$x^2 = d^2+(c-x)^2 \qquad \therefore 2x = c+d^2/c$$
$$\text{But} \quad 2x>a \qquad \therefore c>a-d^2/c$$

A fortiori by (1) $$c>a-\frac{d^2}{a-d} \qquad (3)$$

$$\text{Thus } a-\frac{d^2}{a-d}<c<\sqrt{a^2-d^2}$$

and for $a = 175$, $d = \frac{1}{3}$ we have

$$174.999364<c<174.999682$$

$\therefore c = 174.99952$, correct to the fourth decimal place and there with an error of not more than one-third. Thus $2c = 349.99904$.

II. *Solution by Norman Anning, North Bend, B. C.*

Call the radius r, the chord $2x$ and the angle at the center 2θ.

$$\theta \doteq 175/r \text{ and is very small.}$$

$$(r-\tfrac{1}{3})/r = \cos\theta = 1-\frac{\theta^2}{2}.. \quad \therefore r = \frac{3\cdot 175^2}{2}.$$

$$\frac{x}{r} = \sin\theta = \theta-\frac{\theta^3}{6}, \text{ or } x = 175-\frac{175^3}{6r^2}$$

$$\therefore 2x = 350-\frac{175^3}{3r^2} = 349.999+.$$

III. *Solution by H. E. Trefethen, Waterville, Maine.*

Arc $HEH = s = 350$, $EF = d = \frac{1}{3}$, $EFI =$ the diameter, $FH = c/2$, $O =$ the center, angle $HOH = x$ radians.

1. $EF : EH = EH : EI$, by similar triangles; or approximately $\frac{1}{3} : 175 = 175 : 2R$, since chord $EH =$ arc EH, nearly for so small an angle.

Whence $R = 45937.5$; $x = 350/45937.5$ radians $= 26'\ 11.54''$; $c = 2R \sin(x/2) = 349.9991\ldots$

2. Substituting in $c = s - 8d^2/3s$, a formula sometimes used, we find the same result very nearly, $c = 349.9+$

322. *Proposed by H. E. Trefethen, Waterville, Maine.*

The centers of two circles are A and B. Draw their common tangents with the straight edge only.

Solution by Norman Anning, North Bend, B. C.

The solution of this problem depends upon the following construction: To draw the tangents from a point P to a circle O using straight edge alone. From P draw three secants intersecting the circle in AB, CD and EF respectively. Draw AD and BC intersecting in M, and CF and DE intersecting in N. The line MN will cut the circle in two points X and Y which are the points of tangency with regard to P. Take the case where the circles are mutually exclusive. From the center of each circle draw the tangents to the other. We then have in each circle two lines equally inclined to the common center line. These lines enable us to construct the diameters perpendicular to the common center line. For, the join AB divides the circle A into two semicircles. The two points in either semicircle along with the points where AB cuts the circle are vertices of a cyclic quadrangle whose diagonals intersect on the diameter perpendicular to AB. The joins of the ends of these diameters divide AB at C and D so that

$$AC : CB = AD : DB = \text{radius } A : \text{ radius } B.$$

Construct the tangents from C and D to either circle. They will be the required common tangents. A similar method fits the case when the circles intersect each other.

CREDIT FOR SOLUTIONS.

313. A. J. Beatty, A. G. Bowne, H. C. McMillin. (3)

316 Clarence McCormick. (1)

318. Norman Anning, S. F. Atwood, T. M. Blakslee, Walter C. Eells, John M. Gallagher, A. H. Hughey, R. M. Mathews, Clarence McCormick, H. C. McMillin, C. A. Perrigo, Nelson L. Roray, Elizabeth Sargent, H. H. Seidell, Levi S. Shively, Katherine M. Stewart, H. E. Trefethen, I. L. Winckler. (17)

319. Norman Anning, A. Babbitt, Walter C. Eells, E. B. Escott, W. E. Gibbons, A. M. Harding, A. H. Hughey, R. M. Mathews, Clarence McCormick, H. C. McMillin, Ada M. Messmer, Otto J. Ramler, Nelson L. Roray, Elizabeth Sargent, H. H. Seidell, Levi S. Shively, Katherine M. Stewart, H. E. Trefethen, I. L. Winckler. (19)

320. Norman Anning, A. Babbitt, T. M. Blakslee, R. S. Hardmick, A. H. Hughey, R. M. Mathews, Clarence McCormick, C. A. Perrigo, C. E. Rogers, Nelson L. Roray, Elizabeth Sargent, Levi S. Shively, H. H. Seidell, H. E. Trefethen, I. L. Winckler. (15)

321. Norman Anning, R. M. Mathews, H. C. McMillin, Nelson L. Roray, H. E. Trefethen (3 solutions). (7)

322. Norman Anning, T. M. Blakslee (3 solutions), R. M. Mathews, Nelson L. Roray, Levi S. Shively, H. E. Trefethen, I. L. Winckler. (9)

Total number of solutions, 71.

PROBLEMS FOR SOLUTION.

Algebra.

334. *Selected.*

Factor $a^3(b^2-c^2)^3+b^3(c^2-a^2)^3+c^3(a^2-b^2)^3$.

335. *Proposed by F. Eugene Seymour, Trenton, N. J.*

Find a number of three digits, the last two of which are alike, such that when multiplied by a certain number it still consists of three digits, the first two of which are alike and the same as the former repeated ones, and the third is the same as the multiplier.

Geometry.

336. *Proposed by I. N. Warner, Platteville, Wis.*

Given any point, P, between the sides of a plane angle. Required to construct the two circles which shall pass through this point and also be tangent to the sides of the angle.

337. *Proposed by H. H. Seidell, St. Louis, Mo.*

If three straight lines AA′, BB′, CC′ drawn from the vertices of a triangle ABC to the opposite sides, pass through a common point O, within the triangle, prove

$$\frac{OA'}{AA'}+\frac{OB'}{BB'}+\frac{OC'}{CC'}=1.$$

(Wentworth, p. 247, example 549.)

338. *Proposed by Norman Anning, North Bend, B. C.*

Prove by dissection that the sum of the equilateral triangles described on the legs of a right triangle is equal to the equilateral triangle described on the hypotenuse.

LAND EROSION STUPENDOUS.

The surface of the United States is being removed at the rate of thirteen ten-thousandths of an inch a year, or 1 inch in 760 years, according to the United States Geological Survey. Though this amount seems trivial when spread over the surface of the country, it becomes stupendous when considered as a total, for over 270,000,000 tons of dissolved matter and 513,000,000 tons of suspended matter are transported to tidewater every year by the streams of the United States. This total of 783,000,000 tons represents more than 350,000,000 cubic yards of rock substance, or 610,000,000 cubic yards of surface soil. If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about 73 days.

The amounts removed from different drainage basins show interesting comparisons. In respect to dissoved matter, the southern Pacific basin heads the list with 177 tons per square mile per year, the northern Atlantic basin being next with 130 tons. The rate for the Hudson Bay basin, 28 tons, is lowest; that for the Colorado and western Gulf of Mexico basins is somewhat higher. The denudation estimates for the southern Atlantic basin correspond very closely to those for the entire United States. The amounts are generally lowest for streams in the arid and semiarid regions, because large areas there contribute little or nothing to the run-off. The southern Pacific basin is an important exception to this general rule, presumably because of the extensive practice of irrigation in that area. The amounts are highest in regions of high rainfall, though usually the waters in those sections are not so highly mineralized as the waters of streams in arid regions.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

101. *Proposed by H. M. Swift, Mitchell, S. D*

Is there any text published which gives a Physics course specially adapted to a class of high school girls? If not, is there any magazine article or any other source from which one can obtain a reasonably detailed outline of such a course?

102. *Proposed by H. M. Swift, Mitchell S. D.*

It is reported that gasoline automobile motors will give more power on cold days than on warm days. If that belief is well founded what is the explanation?

103. *Proposed by C. E. Guffin, Wellman-Seaver-Morgan Engineering Co., Cleveland, Ohio.*

An elevator makes 30 round trips per hour. 36 seconds is allowed for stops on each trip. The distance traveled is 164 feet per round trip. The car is hoisted on a two part rope system which winds on a drum of 44″ pitch diameter geared to a motor which makes 425 R. P. M.

What is the necessary gear reduction between motor and drum?

[Note.—The system is such that the motor is reversed to lower the car and runs at the same speed as when lifting the car.]

Solutions and Answers.

99. A calorimeter weighs 65 gm. empty and 327.5 gm. when three-fourths filled with water at room temperature, *i. e.* 14.9° C. Steam is blown in till the temperature becomes 25.1° C. an operation which lasts 1 minute; the temperature falls 0.6° in the next 3 minutes. The calorimeter and contents now weigh 332 gm. Taking the specific heat of the material of the calorimeter as 0.1, find the Latent Heat of steam.

Solution by S. F. Atwood, High School, Dayton, Wash.

Weight of calorimeter empty = 65 gm.
Weight of water in calorimeter = 262.5 gm.
Water equivalent of calorimeter (65x.1) = 6.5 calories.
Water plus water equivalent = 269 calories.
Change in temperature of water (25.1°—14.9°) = 10.2°.
Heat used up (269x10.2) = 2743.8 calories.
Change of temperature of condensed steam (100°—25.1°) = 74.9°.
Weight of steam used (332—327.5) = 4.5 gm.
Heat given off by steam after condensation, while cooling to 25.1° (4.5x74.9) = 337.05 calories.
Heat from condensation of steam (2743.8—337.05) = 2406.75 calories.
Heat given of in condensing by each gram of steam (2406.75÷4.5) = 534.83 calories.
Latent Heat of Steam = 534.83 calories.

[Query.—Should the solution take into account the fact that the calorimeter is only three-fourths full? Should the rate of cooling be taken into account?—*Editor.*]

100. *Proposed by C. A. Perrigo, Dodge, Neb.*

The ratio of the masses of the moon and the earth is .0125 and the ratio of their diameter is .273. With what acceleration would a body fall at the moon's surface?

Solution by Edison Pettit, Minden, Neb.

When the mass of the attracting body is enormous compared with that of the attracted body Newton's equation is

$$i = c\frac{m}{r^2}$$

(equation (1), page 57 of the January issue), where i is the intensity of the attraction, c a constant depending on the units employed, m the mass of the attracting body and r the distance between the centers of gravity of the bodies. This equation then will express the intensity of attraction on the earth and moon. Now the intensity of attraction is measured by the acceleration given to the falling body, *i. e.*, the intensities are to each other as the accelerations, hence if $g =$ the acceleration at the earth's surface, g' the acceleration on the moon, I the intensity of attraction on the earth and i the intensity of attraction on the moon we have

$$\frac{g'}{g} = \frac{i}{\mathrm{I}}.$$

Let M be the mass of the earth, m the mass of the moon, R the radius of the earth and r the radius of the moon, then

$$\frac{i}{\mathrm{I}} = \frac{c\dfrac{m}{r^2}}{c\dfrac{\mathrm{M}}{\mathrm{R}^2}} = \frac{m\mathrm{R}^2}{\mathrm{M}r^2}$$

$$\text{hence } \frac{g'}{g} = \frac{m\mathrm{R}^2}{\mathrm{M}r^2}$$

$$\text{and } g' = \frac{gm\mathrm{R}^2}{\mathrm{M}r^2}.$$

Now $g = 32.16$ feet, and by the problem $m = .0125$ M and $r = .273$ R, hence

$$g' = \frac{32.16\text{x}.0125\mathrm{MR}^2}{\mathrm{M}\text{x}(.273)^2\mathrm{R}^2} = \frac{32.16\text{x}.0125}{(.273)^2} = 5.39 \text{ feet per second.}$$

Solutions also received as follows:

92. C. A. Smith, Oakland, Iowa.
93. C. A. Smith, Oakland, Iowa.
97. S. F. Atwood, Dayton, Wash.
100. C. A. Perrigo, Dodge, Neb. *Answer* 163.6+cm./sec.^{2}

Frank L. Cooper, New Haven, Conn. *Answer* 164+cm./sec.^{2}

AN OBJECTION.

By Wm. A. Hedrick,

McKinley Manual Training School, Washington, D. C.

On page 726 of School Science and Mathematics (November, 1912) an answer is obtained by dividing a weight by a weight thus getting gm./cc. In (c) a weight is subtracted from a weight and volume in cc. obtained.

I like the children to use the English system of units so that they cannot *by subtraction* change the denomination.

UNSOLVED PROBLEMS.

[The following request for information was sent to the Editor of *Science Questions*. Address answers to Dr. R. C. Benner, University of Pittsburgh, Pittsburgh, Pa.]

In your work, you, without doubt, come in contact with many problems, which, because of the lack of time or facilities for solving, you do not work out, but which would be of value, if solved. On the other hand, many, who possess the time and facilities, have no means of acquainting themselves with the problems of practical value.

With this in view, I am preparing a series of articles on the unsolved problems in Industrial Chemistry and Metallurgy (especially the fume problem). The major part of the information to be utilized, will come, of necessity, from my brother chemists and metallurgists. Therefore, I am writing you at this time to solicit any information you may be willing to give concerning unsolved problems with which you are acquainted.

OPEN BOOK TESTS.

By A. P. Andrews,
Central High School, Minneapolis, Minn.

The following questions were given in an open book test in Physics to cover articles 305 to 375, Millikan and Gale. If anyone should decide to try this set in an open book test, I would be very much interested in learning the result. In my own experience I find as the invariable result, a sifting of the thinkers from the memorizers.

Time: 45 Minutes. Answer All.

1. What experiment furnishes the strongest proof for our belief that the molecules of magnetic substances are permanent magnets?
2. A charged ebonite rod is brought near an uncharged electroscope. What will be the effect on the leaves? How will the same rod affect a negatively charged electroscope?
3. If it takes 100 units of charge to raise the potential of a condenser to 25 volts, what is the capacity of the condenser?
4. A magnetic needle is held under a trolley wire in which the current flows from east to west. Which way will the N pole turn? Why?
5. Upon what does specific resistance depend?
6. A certain length of wire has a resistance of 10 ohms, and a diameter of .08 mm. What is the resistance of another wire of the same material and length, but having a diameter of .32 mm.?

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

The Kansas Association of Mathematics Teachers held its annual meeting, Friday, November 8, 1912, at Topeka, Kan. The meeting was called to order by the President, W. H. Andrews of the Kansas State Agricultural College. The program given was as follows:

1. "The Future of Our Geometry," David Eugene Smith, Columbia University, New York City.
2. "Some Shortcomings of the College Freshman in High School Mathematics," Willard H. Garret, Baker University.
3. "The Vitalization Movement in Elementary Geometry," Benjamin L. Remick, Kansas State Agricultural College.
4. Business session.

The question of having a second meeting of the association during the year was discussed, but no definite action was taken.

On motion it was decided that a register of the association be published this year.

The officers for the ensuing year are: Fiske Allen, Emporia, President; R. S. Lawrence, Wichita, Vice-President; Eleanora Harris, Hutchinson, Secretary-Treasurer.

INDIANA STATE SCIENCE AND MATHEMATICS ASSOCIATION MEETING.

This association will hold its next meeting at the Manual Training High School, Indianapolis, Indiana, March 7th and 8th. An excellent program has been arranged and all science and mathematics teachers in the state should attend. It will be worth while. Write the secretary, Ernest S. Tillman, High School, Hammond, Ind. for information.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

The New York State Science Teachers' Association held its seventeenth annual meeting at Syracuse, December 26th-28th. It proved to be one of the best in our history, a large number being in attendance and the papers and discussions proving most valuable. Over forty new members have been received since our last meeting.

Following the Thursday afternoon informal meeting and registration, the members joined with the Associated Academic Principals and other educational bodies in a general meeting in the evening.

The retiring President, L. S. Hawkins of the State Education Dept. called the meeting to order Friday morning and introduced President elect, Ernest R. Smith, North High School, Syracuse, who made a brief address. Dr. C. F. Hale, State Normal College, Albany, then gave an especially interesting and instructive talk on "The Manufacture of the Modern Incandescent Electric Lamp." Possessed of a practical, first-hand knowledge of the subject, that comes to one who has had the privilege of working in the research laboratories of the General Electric Co., Dr. Hale was able to hand over to the Association facts of interest and value concerning the incandescent lamp of yesterday and to-day. Various specimens of material were shown, also parts showing different stages in the manufacture.

After the general session, the various sections met for their special programs. To section A (Physics and Chemistry), chairman C. Brooks Hersey, Maston Park High School, Buffalo, introduced Dexter S. Kimball, Professor of Machine Design and Construction, Cornell University, who spoke on "Mechanics and its Relation to the Shop." Mr. Kimball first emphasized the fact that all our work along educational lines should be to uplift and benefit human lives. He said that aside from inherent ability, the accomplishments that industrial workers must possess are: (1) Manual skill, (2) Industrial or manufacturing knowledge, (3) Scientific knowledge and the ability to use it. "Men seldom add to their scientific base line after leaving school." "This," he remarked, "is history."

F. F. Good, Teachers College, Columbia University, then read an excellent paper on "Physics in the School of Practical Arts." Mr. Good demonstrated some of his arguments by means of a clock made by his pupils.

Section B (Biology), of which J. F. Hummer, Potsdam Normal School, was chairman, first listened to Miss Gladys Miller, Troy High School, who read a paper on "Efficient Lines of Appeal in Biology Teaching," following which T. J. Moon, High School, Middletown, outlined a course in Advanced Zoology that he is offering to some of his pupils, and advocated a wider use of advanced work. A spirited discussion followed these papers.

J. E. Woodland, Mechanics Institute, Rochester, who was on the program of section C (Home Economics) gave his talk on "Household Physics and Chemistry" before the joint meeting of sections A and C. This was an extremely practical talk, full of helpful suggestions, which urged the bringing of practical teaching closer to the pupils.

Section meetings were again resumed Friday afternoon. In section A, "Communal Chemistry" was the subject of the talk given by Lewis B. Allyn, State Normal School, Westfield, Mass. Mr. Allyn suggested many ways in which we could bring the practical applications of Chemistry and our teaching of the subject closer together and showed some commercial products, as flavoring extracts, etc., the true nature of which should be better known.

Harry A. Carpenter, West High School, Rochester, made a brief report on "The High School Chemistry Problem" in which he indicated some of the "dead wood" in Chemistry courses. This was followed by a report of the committee on "Practical Laboratory Experiments" by the chairman, Dr. John F. Woodhull, Teachers College, Columbia University. One of the facts brought out by Dr. Woodhull was: Of the high school pupils in New York State, there are 48% in the 1st year class, 26% in the 2nd year class, 16% in the 3rd year class and 10% in the 4th year class. 8% graduate, 4% prepare for college and only 2% of the total number of high school pupils are admitted to college. F. A. Saunders, Syracuse University, then gave a very interesting demonstration of an apparatus for projecting the effect of sound waves on a screen. This brought forth hearty applause from all present.

There were no set papers prepared for section B for Friday afternoon, the program calling for open discussions on several important topics. A great deal of interest was shown in this conference and many helpful suggestions were made.

Before section C, H. B. Smith, State Normal College, Albany, gave a valuable talk on the subject, "Uncle Sam: Merchant or Customer." One of the most satisfactory and helpful features of the whole program was the "Get Together" meeting Friday evening held in some of the members' hotel rooms. "Free for all" discussion was had along many live lines of interest.

An unusually large number remained for the Saturday morning meeting which opened with a general session. Miss Isabel Lord, Pratt Institute, Brooklyn, was the first speaker. She discussed "The Education of the Girl" in a very interesting and helpful manner. This was followed by a business meeting after which the final meetings of the sections were held, section C joining with section A.

Miss Grace MacLeod, Pratt Institute, Brooklyn, was the first speaker before sections A and C. Her topic was "Practical Physics for Domestic Science Students" and she clearly brought out the fact that girls are as apt and quick to apply physical principles to practical applications in life as are the boys. Dr. C. W. Hargitt, Syracuse University, spoke on "Some Newer Aims in Biology Teaching" before section B, and was followed by Wm. L. Bray, Syracuse University, who read a paper on "Relation of Biology to Agriculture." Both of these papers were excellent.

During the morning meeting Dr. Chas. F. Wheelock, State Education Dept., Albany, spoke encouragingly concerning the attitude which the Department takes regarding improvements in Science teaching. He said any science teacher who wishes to outline a course

of his own may do so and submit the same to the Department for approval. In case the Department approves, the course may be followed by that teacher.

J. A. Randall, Pratt Institute, Brooklyn, made a brief report indicating the progress that is being made by the committee on "Practical Laboratory Experiments." Following this the meeting adjourned. The following officers were elected for the year 1913: President, Frederick A. Saunders, Syracuse University; Vice President, Bryan O. Burgin, High School, Albany; Sec.-Treas., Ernest F. Conway, Central High School, Syracuse. BRYAN O. BURGIN.

MINUTES OF THE PHYSICS SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Physics and Chemistry Sections of the Central Association of Science and Mathematics Teachers met in joint session in the Physics Lecture Room in Science Hall, Northwestern University, Evanston, Friday afternoon, Nov. 29, 1912. The meeting was called to order by Mr. E. E. Burns, chairman of the Physics Section. Mr. Burns announced that the two programs of the Physics Section which had been prepared for Friday afternoon and Saturday forenoon would be given that afternoon in order that the members of the section might attend a meeting of the American Physical Society which would meet in the same room Saturday forenoon. Chairman Burns appointed the following nominating committee for the Physics Section: Chas. M. Turton, Bowen High School, Chicago, chairman; Chas. H. Perrine, Wendell Phillips High School, Chicago; H. L. Terry, State High School Inspector, Madison, Wis.

Mr. Burns then called on Mr. J. W. Shepherd, chairman of the Chemistry Section, to introduce Dr. Herbert N. McCoy, the speaker before the joint session. "Recent Advances in Radio-activity" was the subject of Dr. McCoy's paper. Dr. McCoy presented the series of radio-active elements and discussed the period of activity, the range, and the emanations of each. He explained how each of these phenomena was determined and measured. His paper dealt especially with the contributions that recent study of radio-active elements has thrown on the constitution of matter, the relation of the chemical elements, and the age of the elements. It is hoped that the paper read by Dr. McCoy will be published in the proceedings of the Association.

The members of the Chemistry Section then retired to the Chemistry Lecture Room of Science Hall for the remainder of their program.

Prof. A. P. Carman, University of Illinois, gave the second paper before the Physics Section upon "Some Recent Physical Theory and Its Bearing on the Teaching of the Elements of Physics." Prof. Carman discussed the beginning and the development of the electron theory and its replacement of the ether theory. He showed how the electron theory has come to explain the phenomena of magnetism, electricity, light, and even heat, and he drew the conclusion that what has for so long a time been called "ether" is not necessary for the explanation of the various phenomena.

This paper brought forth a lively discussion and some very pointed questions were asked Prof. Carman by C. F. Adams, Dr. Mann, Chas. M. Turton, and others. Some of the questions asked were: "Do we not measure what we call the 'wave length' of light?" "How can this be if there is no ether?" "Is the corpuscular theory a real explanation of a

real phenomena?" "Shall we dodge the explanation of phenomena to high school students?" Prof. Carman's paper was published in the January issue of SCHOOL SCIENCE AND MATHEMATICS, and should be widely read and discussed.

The next number on the program was the presentation and illustration of an electrical apparatus by Mr. C. F. Adams, Central High School, Detroit. Mr. Adams remarked that he did not believe in "cure alls," nor in a single apparatus that could illustrate all things, yet when he had shown what he could do with his new apparatus the members of the section felt that he had combined many principles into this one piece of apparatus. Mr. Adams originally made his apparatus to illustrate Ampere's rules of electric currents, but perfected it to illustrate in addition the principles of the D'Arsonval galvonometer, the magneto, the dynamo, and the motor, both for A. C. and for D. C. currents. Many favorable comments were made concerning this apparatus. This paper is published in the March issue of SCHOOL SCIENCE AND MATHEMATICS.

Mr. W. E. Tower next gave a report of the committee on "Segregation in Physics Classes." Mr. Tower gave the substance of the replies to questions which he sent out to teachers who are trying the plan of segregating physics classes. The conclusion reached from the replies received was that best results are obtained when the classes in physics are segregated. He concluded his report by recommending that efficiency tests be given these and other classes to determine the real value of segregation.

Mr. F. E. Goodell, North Des Moines High School, Des Moines, Iowa, gave a report of the committee appointed a year ago upon "Efficiency Tests." Mr. Goodell's report was based on replies which he received from a questionaire sent to some sixty teachers of physics. He gave verbatim the replies of several teachers in answer to his first question, viz., "Is a knowledge of physics the aim in our teaching of the subject?" Mr. Goodell drew the conclusion from the replies received that the teachers of physics are not trying new methods for testing for efficiency, but seem rather to be content with the old ways of teaching.

At the conclusion of the report the motion was made and carried that the same committee be continued for another year and that it investigate further and report at the next annual meeting. As a result of this motion Mr. Goodell requested that all present who would co-operate with his committee this coming year give him their name and address. A great many responded to the request.

A lively discussion, based particularly upon the replies that Mr. Fred R. Nichols, Crane High School, Chicago, received from his eighty pupils in physics in answer to the question, "What have you learned from the study of physics?", followed Mr. Goodell's report.

Chairman Burns adjourned the section to meet in executive session at 9:30 a. m., Saturday, in the Physics Room in Fisk Hall.

The Physics Section met in executive session in the Auditorium of Fisk Hall at 10:15 Saturday forenoon. The Nominating Committee reported the following nominations:

Chairman—C. F. Adams, Central High School, Detroit.

Vice-Chairman—H. R. Smith, Deerfield Township High School, Highland Park, Ill.

Secretary—A. A. Upham, State Normal School, Whitewater, Wis.

A motion was made and seconded that the report of the Nominating Committee be accepted, and that the persons named be the officers for the ensuing year. The motion was carried. The meeting then adjourned.

E. P. REYNOLDS, *Secretary.*

ARTICLES IN CURRENT PERIODICALS.

American Naturalist for January; *Garrison, New York; $4.00 per year, 40c a copy:* "Factors and Unit Characters in Mendelian Heredity," T. H. Morgan; "Vertical Distribution of the Chætognatha of the San Diego Region in Relation to the Question of Isolation vs. Coincidence," Ellis L. Michael; "A Family of Spotted Negroes," Q. I. Simpson and W. E. Castle; "The Effect of Fertilizers on Variation in Corn and Beans," J. K. Shaw.

Botanical Gazette for January; *University of Chicago Press; $7.00 per year, 75c a copy:* "The Climax Forest of Isle Royale, Lake Superior, and Its Development," William S. Cooper; "Progressive and Retogressive Changes in the Plant Associations of the Delaware Coast," Laetitia M. Snow; "Ray Tracheids in the Coniferales," Ruth Holden; "The Life History of Gloeotaenium," Edgar N. Transeon; "Revegetation of a Denuded Area," H. S. Conrad.

Catholic Educational Review for January; *Catholic Education Press, Washington, D. C.; $3.00 per year, 35c a copy:* "Education in Ancient China," William Turner; "Some Problems of Correlation," Brother Leo; "The Church and Agricultural Education," Brother Valentine; "Application of the Principles of the Sandboard in Class Work," Emma G. Sullivan.

For February: "The Motion Picture Drama in the School," John Talbot Smith; "Feeling and Mental Development," Thomas Edward Shields; "The Devil is a Cheerful Cuss," The Cheerful Confidant.

Condor for November-December; *Eagle Rock, Los Angeles, Calif.:* "Study of the Eggs of the Meleagridae" (with one photo), R. W. Shufeldt; "Nesting of the Rocky Mountain Nuthatch" (with two photos), F. C. Willard; "A Horseback Trip Across Montana," Aretas A. Saunders; "Nesting Habits of the Western Bluebird," Harriet Williams Myers.

Educational Psychology for December; *Warwick and York, Baltimore, Md.; $1.50 per year, 20c a copy:* "Problems in the Experimental Pedagogy of Geometry," W. H. Metzler; "An Investigation of the Value of Drill Work in the Fundamental Operations of Arithmetic, Part II," J. C. Brown; "The Child's Speech. III. Speech Without Words," Robert MacDougall; "The Influence of Environment on Mental Ability as Shown by Binet-Simon Tests," Joseph Weintrob and Raleigh Weintrob.

For January: "Problems in the Scientific Study of the Teaching of Arithmetic," C. W. Stone; "Mental Adaptation During the School Day, as Measured by Arithmetical Reasoning," W. H. Winch; "The Child's Speech. IV. Word and Meaning," Robert MacDougall.

Educational Review for January; *Easton, Pa.; $3.00 per year, 35c a copy:* "The International Commission on the Teaching of Mathematics," David Eugene Smith; "Loss of Efficiency in the Recitation," Theodore C. Mitchell; "The Executive Values in Education," M. O. B. Wilkinson; "Study of Religion in the University," John W. Buckham; "Methods of Ascertaining and Apportioning Cost of Instruction in Universities," Arthur T. Hadley.

Education for January; *120 Boylston St., Boston; $3.00 per year, 35c a copy:* "Entrance Requirements and the College Degree. The Degree for College plus School Work," Charles H. Forbes, Henry Thacher Fowler; "The Degree for College Work Only," Charles W. Parmenter, Edmund C. Sanford; "Honesty in School Work," D. W. Abercrombie; "Student Honesty in College," William Lyon Phelps; "The Honor System of the University of Virginia," William S. A. Pott; "The Honor System at Princeton," Maxwell Chapman; "The Honor System of Sheffield Scientific School," Alexander Wallace Chauncey.

Mathematical Gazette for January; *G. Bell and Sons, Portugal St., Kingsway, London; 6 no. 9s, 1s, 6d a copy:* "The Teaching of Limits and Convergence to Scholarship Candidates, II (*Continued*)," W. P. Milne; "A Case of Three Rotating Lines and the Point 'O' (*Continued*)," F. Glanville Taylor; "Reform of Mathematical Teaching in Germany (*Continued*)," E. Allan Price. *Special Commemorative Issue:* "Intro-

duction"; "Biographical Notes," Edward M. Langley, W. J. Greenstreet; "Some Principles of Mathematical Education," G. St. L. Carson; "On a Symbolic Proof of Fourier's Theorem," L. N. G. Filon; "On Surfaces Traced Out by the Motion of an Invariable Curve," Harold Hilton; "A Problem in Probability," C. S. Jackson; "A Graphic Solution of the Equation $z^n - px + q = o$," A. Lodge.

National Geographic Magazine for December; *Washington, D. C.; $2.50 per year, 25c a copy:* "East of the Adriatic: Notes on Dalmatia, Montenegro, Bosnia, and Herzegovina (with 37 illustrations)," Kenneth McKenzie; "The Land of Contrast: Austria-Hungary (with 33 illustrations)," D. W. and A. S. Iddings; "Notes on Rumania (with 8 illustrations)"; "The Origin of Stefansson's Blond Eskimo (with 10 illustrations and map)," Major. Gen. A. W. Greely, U. S. Army; "The Tailed People of Nigeria) (illustrated)"; "Sunrise and Sunset from Mount Sinai (with 34 illustrations)," Rev. Sartell Prentice, Jr., D. D.

Nature-Study Review for January; *School of Education, University of Chicago; $1.00 per year, 15c a copy:* "Instruction in Agriculture," B. M. Davis; "Tree Study in Winter," A. M. Blakeslee; "Common Rocks," W. A. Tarr; "Hygiene as Nature Study, IV," F. M. Gregg.

Photo-Era for January; *383 Boylston St., Boston; $1.50 per year, 15c a copy:* "Photographic Home-Amusements," Wilfred A. French; "Lantern-Slides by the Powder-Process," Harold Holcroft; "Ninth American Photographic Salon," R. L. Sleeth, Jr.; "The Adventures of a Winter-Night," Phil. M. Riley.

Popular Astronomy for February; *Northfield, Minn.; $3.50 per year, 35c a copy:* "Recent Changes in the Northern Equatorial Belt of Jupiter," Latimer J. Wilson; "The Debt Which Astronomy Owes to Ormsby MacKnight Mitchell," Everett Yowell; "Astronomy in the High School, VI. First Use of Opera Glasses," Mary E. Byrd; "The Development of Cosmological Ideas," Hector MacPherson, Jr.; "Observatory at Antietam Farm, Smithtown, Long Island," R. Burnside Potter.

Popular Science Monthly for February; *Garrison, New York; $3.00 per year, 30c a copy:* "The Geologic History of China and Its Influence on the Chinese People," Eliot Blackwelder; "French Geodesy," The Late Henri Poincaré; "The Rôle of Membranes in Cell-processes," Ralph S. Lillie; "The Problem of the Efficiency of Labor," Howard T. Lewis; "Bergson's View of Organic Evolution," Dr. Hervey W. Shimer; "The Abilities of an 'Educated' Horse," M. V. O'Shea; "The Advancement of Psychological Medicine," Dr. Frederic Lyman Wells; Immense Salt Concretions," Professor Frederic G. D. Harris; "College or University," Dr. Stewart Paton.

Psychological Clinic for January; *College Hall, Philadelphia, Pa.; $1.50 per year, 20c a copy:* "Age and Progress in a New York City School," William E. Grady, Principal Public School No. 64, Manhattan, New York City; "Retardation in Nebraska," William Henry Stephenson Morton, Superintendent of Schools, Ashland, Neb.; "Language Development in 285 Idiots and Imbeciles," Clara Harrison Town, Director of the Department of Clinical Psychology, Lincoln State School and Colony, Lincoln, Ill.

School Review for January; *University of Chicago Press; $1.50 per year, 20c a copy:* "The Duplication of School Work by the College," James Rowland Angell; "The Meaning of Secondary Education," Charles H. Judd; "A Plea for Out-of-Door Zoölogy," Walter L. Hahn.

School World for January; *Macamillan and Company, London, Eng.; 7s, 6d per year, 6 pence a copy:* "English Texts for Schools," Norman L. Frazer; "Teachers' Certificates of Proficiency"; "The State Leaving Certificate of Scottish Schools, With Special Reference to the Qualifying Examination of the Primary Stage (with diagram)," D. Macgillivray; "'Cramming' for Civil Service Examinations"; "The Teaching of Scholarship Mathematics in Secondary Schools," William P. Milne; "The Teaching of Geometry," W. D. Eggar.

Teachers' College Record for November; *Teachers' College, New York City:* "Play and Recreation in Arithmetic," Charles W. Hunt; "Mathe-

matical Games—Adaptations from Games Old and New," Florence James Flynn; "Rithmomachia, the Great Medieval Number Game," David Eugene Smith and Clara C. Eaton; "The Great Number Game of Dice," David Eugene Smith; "The Origin and Development of the Number Rhyme," David Eugene Smith; "The Number Rhymes of Metrodorus," Robert King Atwell; "Number Games Bordering on Arithmetic and Algebra," Frances B. Selkin.

Terrestrial Magnetism and Atmospheric Electricity for December; *Johns Hopkins Press, Baltimore; $3.00 per year, 90c a copy:* "Preliminary Note on an Attempt to Detect the General Magnetic Field of the Sun," G. E. Hale; "Ueber die Gegenseitige Einwirkung Zweier Magnete in Beliebiger Lage," Adolf Schmidt; "Alibag Magnetic Observatory," N. A. F. Moos.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 8; *Otto Salle, Berlin W. 57, 8 No. M. 4, 60 pf. a copy:* "Die beiden Wege zur Ableitung der barometrischen Höhenformel," Prof. Dr. Emil Schulze; "Die Wirkungen des Radiums auf den Organismus," Dr. V. Franz; "Ueber Talsperrenplankton," Dr. phil. Georg Schneider; "Die anschaulich-geometriche Methode der Quadratwurzerausziehung," Dr. R. Hunger; "Zum euklidischen Beweis des nythagoreischen Lahrsatzes," Oberlehrer M. Linnich; "Goniometrische Gleichungen," Oberlehrer H. Milz; "Das Foncaultische Pendel," Dr. G. Berkhan.

Zeitschrift für den Physikalischen und Chemischen Unterricht for November; *Prof. Dr. F. Paske, Berlin-Dahlem, Friedbergstrasse 5, 6 number $2.88, M. 12 per year:* "Solenoid-Galvanoskope für Schülerübungen," B. Kolbe; "Ein Strom- und Resonanzpendel," P. Spies, "Messende Versuche mit dem Drucke der Wasserleitung," H. Rebenstorff; "Über ein einfaches Reversionspendel," P. Bräuer; Über die Bestimmung des Ausdehnungs-koeffizienten des Quecksilbers mit einem Dilatometer aus Quarzglas," P. Bräuer; "Ein Apparat zur Bestimmung der Schwingungszahl einer Stimmgabel für Demonstration und Schülerübungen," F. Schütte; "Eine optische Bank zur Demonstration des Zielfernrohrs und des Ablesemikroskops," P. Werkmeister; "Vorlesungsversuch zur Autoxydation des Eisens und zur katalytischen Wirkung des Wasserdampfes," O. Ohmann; Kleine Mitteilungen: "Ein Jahreszeitenapparat zur Selbstanfertigung," H. Knoll; "Eine Schülerübung über die totale Reflexion," K. Straus.

DOCTORS OF PUBLIC HEALTH.

"We need more doctors of public health than mere doctors of medicine," says Dr. F. B. Dresslar in a bulletin, "The Duty of the State in Medical Inspection of Schools," just issued by the United States Bureau of Education. Dr. Dresslar pleads earnestly for the kind of medical inspection that seeks to promote health rather than that which hunts for ill-health. "Our system of paying doctors to do something for us when we are sick ought to be largely discarded for the Chinese system of paying them to keep us from getting sick."

Dr. Dresslar justifies the State's intervention in the health of its citizens on broad grounds of public policy. He feels that the community has as much right to demand good health in its children as it has to demand that they attend school; as much right to preserve the community against the contagion of disease and bodily neglect as against the contagion of ignorance. The chief asset of any state is physical stamina, guided by wholesome, moral ideals, and broad-minded intellectual power, and Dr. Dresslar contends that medical inspection and health supervision are indispensable agencies for conserving this asset.

In answer to the question: Has medical inspection as now organized proved useful? Dr. Dresslar shows conclusively that medical

inspection has called attention in a startling way to the danger of school conditions in transmitting disease; it has already lessened actual illness and consequently secured better school attendance; and best of all, medical inspection in the hands of carefully trained men with the right spirit has proved to be an educational agent of great value, by stimulating parents to give more attention to food, clothing, sleeping rooms and general home sanitation, and by disseminating better ideals of hygienic living.

It is in this increased knowledge by the people as a whole concerning the personal care of health that Dr. Dresslar finds the greatest ultimate good of medical inspection. He notes that great numbers of our people are still in gross ignorance and superstition regarding health and disease, since many of them constantly attribute to a divine Providence deaths from diseases directly due to filth. "Our chief duty lies in removing the causes which contribute to physical unsoundness and disease. As long as we herd our children in schools where they must breathe impure air, bend over insanitary school desks, work at books when they need physical exercise, just so long shall we be paying for our own errors."

Dr. Dresslar concludes that we need health officers whose chief delight is in finding and developing beautiful cases of physical perfection rather than in finding some obscure and rare disease; health officers whose philosophy is based on the gospel of physical vigor, on the sanctity of personal purity and the godliness of clean-living; "doctors of health" in very truth, who will be concerned with exhibiting, not a long list of the physically defective and diseased, but a large list of healthy, well-developed children.

HONESTY IN PUBLIC HEALTH WORK.

The attitude of the public toward epidemics in past years has been either one of mystery or of panic. Pestilence has been regarded as something to placate by magic or to flee from in terror. But in the last half century, disease has been largely robbed of both its mystery and its fearsomeness. We know it now as a product of natural causes, to be met and overcome by common sense and expert knowledge. The importance of social conditions in the production of disease has been recognized, as well as the public responsibility for its existence. The public and the physicians are now recognized as coworkers in the suppression of disease. If partners in this work, it is only fair that both parties should know the facts, and that, in times of epidemic disease, the public should be told the whole truth. This important obligation of the modern health officer is recognized by Dr. Juan Guiteras, Health Officer of Havana. In a recent issue of *The Journal of the American Medical Association*, in an article on Bubonic Plague in Havana, Dr. Guiteras condemns the old policy of suppression of facts and says: "I have contended for the following fundamental rule in sanitary practice: Work must be done in the broad daylight; the people should know what we are doing, and what to expect. If we never deceive them, they will believe what we say; we obtain their co-operation, we minimize panic, and we can begin active operations at once. All this is the most elemental common sense; but, strange to say, the general acceptance of this golden rule has been slow and difficult. Only last year the presence of cholera was concealed in several communities. Such deception was dangerous to the infected region, and, to the uninfected neighbors, it was cruel and inhuman."

REQUISITES OF GOOD GLASS SAND.

Sand is the main constituent of glass, constituting from 52 to 65 per cent of the mass of the original mixture, or from 60 to 75 per cent of the finished product after melting has driven off carbon dioxide and other volatile materials. On the quality of the sand depend the transparency, brilliancy, and hardness of the glass. For the finest flint ware, such as that used for optical and cut glass, "water whiteness," absolute transparency, great brilliance, and uniform density are required, and only the purest sand can be employed, since slight impurities, especially small quantities of iron, tend to destroy these effects. For plate and window glass, which are commonly pale green, absolute purity is not so essential but generally the sand should not carry more than 0.2 per cent of iron oxide. Green and amber glass for bottles, jars, and rough structural work can be made from sand relatively high in impurities. An excess of the chief impurity, iron, is usually avoided in the quarries by a careful selection of the whitest sand, although the whitest sand is not invariably the purest. Repeated washing tends to remove the iron. Magnetic separators also have been resorted to, especially when the iron is present in the form of magnetite. Clay materials are objectionable because they cloud the glass. Washing helps to remove them, since they occur usually in a very finely divided state. Magnesia, which is more apt to be introduced into glass materials through limestone than through sand, is troublesome because it renders the batch less fusible. In examining sand in order to ascertain its value for glass making, inspection with a magnifying glass is the best preliminary test. The following points should be observed: The sand should be nearly white and of medium fineness (passing a 20 to 50 mesh horizontal sieve); the grains should be uniform in size, even, and angular; less preferably they may be rounded. A simple chemical test consists in heating the sand in a dilute acid. Effervescence indicates the presence of lime; loss of color shows the presence of clay impurities. Iron in the most minute quantity may be detected by dissolving sand in hydrofluoric acid and adding potassium ferrocyanide, which produces a blue precipitate if iron is present. Complete quantitative analyses as well as a furnace test should be made as a final determination of the character of a prospective glass sand.

(From Advance Chapter, Mineral Resources of the United States for 1911.)

DANGERS OF COMMON COLDS.

Ever since the influenza epidemic of 1889-90 we have experienced waves of infectious catarrhal colds which have been spoken of as influenza, or grip, or simply as colds. To these infections the infant seems to be especially susceptible. When one of these colds invades a household, several of its members usually contract it. While some adults may escape, the baby or the child of runabout age is almost invariably affected. These infections spread rapidly and with great certainty through the wards of institutions caring for young children. During recent winters in one institution the sickness from this source has far exceeded that from all other infectious diseases of childhood. One of the most important results is its interference with nutrition. This is of somewhat less importance among children of the runabout age, but in any group of bottle-fed infants such infection not only prevents gain but is, as a rule, accompanied by def-

inite loss in weight. We are too prone to look on these colds as local affections when they are, in reality, infections.

When a group of children in a family becomes infected, we often see established a house infection with, at intervals, recurrent outbreaks, which may extend over a number of months, until the advent of warm weather or the departure of the family to the country. This experience is so general in New York as to be a matter of common report among parents. Some susceptible children are kept free only by continued residence in the country, but unfortunately suburban colonies and country towns have their own share of infectious epidemics.

The amount of injury done young children each year by such colds can scarcely be estimated. During the prevalence of such colds, the possibilities of infection are excellent if the young child travels by train, rides in public conveyances or is taken to hotels or crowded shops.

Only recently, says Dr. Thomas S. Southworth of Boston, in a recent issue of *The Journal of the American Medical Association,* have we begun to appreciate the ravages of these subtle forms of infection. With such knowledge, however, goes the moral obligation to throw off our indifference, to face the question fairly, and to do all in our power to lessen the unnecessary sickness and the too frequent pneumonia which follows it.

BOOKS RECEIVED.

Annual Report of the Superintendent of Schools, Cleveland, by William H. Elson. Pages vii+70. 13x21 cm. Paper, 1911. Board of Education, Cleveland.

Edgar County, Illinois, Public Schools Annual. By Geo. W. Burns, Superintendent. 144 pages. 15x22 cm. Paper, 1912. Gazette Press, Paris, Ill.

Eleventh Report of the Home for the Training in Speech of Deaf Children. By the Trustees. 2201 Belmont Ave., Philadelphia.

Mineral Science. A Study of Inorganic Nature. By Miner H. Paddock. Technical High School, Providence. Pages xiv+148. 13x18 cm. Cloth, 1911. 60 cents. Benj. H. Sanborn & Co., New York.

Genetics, An Introduction to the Study of Heredity. By Herbert Eugene Walter, Brown University. Pages xiv+272. 13x20 cm. 1913, cloth. $1.50, net. Macmillan Company, New York.

Development of the Human Body. By J. Playfair McMurrich, University of Toronto. Pages x+495. 14x20 cm. 1913, Cloth. $2.50, net. P. Blakiston's Son and Co., Philadelphia.

Household Bacteriology. By Estelle D. Buchanan and Robert Earlè Buchanan, Iowa State College. Pages xv+536. 13x19 cm. 1913, Cloth. $2.25, net. The Macmillan Company, New York.

Notes on Chemical Research. By W. P. Dreaper, Editor of the Chemical World. Pages x+68. 11x19 cm. 1913, Cloth. $1.00, net. P. Blakiston's Son and Co., Philadelphia.

Physical Laboratory Guide. By Frederick C. Reeve, Newark, New Jersey, Academy. Pages x+182. 13x19 cm. 1912, Cloth. American Book Co., Chicago.

Hygiene for the Worker. By William H. Tolman and Adelaide Wood Guthrie, New York. Pages vii+231. 1912, Cloth. American Book Co., Chicago.

A History of Chemistry from the Earliest Times Till the Present Day. By James C. Brown, University of Liverpool. Pages xxix+543. 15 x 23 cm. 1913, Cloth. $3.50, net. P. Blakiston's Son and Co., Philadelphia.

Who's Who in Science, International. By H. H. Stephenson. Pages xvi+572. 15x23 cm. 1913, Cloth. J. & A. Churchill, 7 Great Marlborough Street, London.

A Text-Book of Physics. By S. E. Coleman, Oakland High School. Pages ix+649. 13x19 cm. 1911, Cloth. D. C. Heath & Company, Chicago.

BOOK REVIEWS.

Source Book of Problems for Geometry, by Mabel Sykes, Instructor in Mathematics in the Bowen High School, Chicago. Pages viii+372. 14x20 cm. 1912. Allyn and Bacon, Boston.

The author and publishers are to be congratulated on the appearance of this volume. It reminds one of the painstaking care and wide research of the German writers of mathematical books, and shows that there is great opportunity for teachers of secondary mathematics to investigate some definite portion of their mathematical field and publish the results of their systematic inquiry for the benefit of others.

The six chapters of the book give a discussion of the following topics: (1) Tile Designs, (2) Parquet Floor Designs, (3) Miscellaneous Industries, (4) Gothic Tracery: Forms in Circles, (5) Gothic Tracery: Pointed Forms, (6) Trusses and Arches. The occurrence of geometrical forms in tiles, mosaics, iron grills, steel ceilings, tracery of windows and other architectural designs, needlework, jewelry, and so on, not only gives some excellent drill work in arithmetic, algebra, and geometry, but also reveals the importance of geometry in the construction of decorative and useful designs. The historical accounts of the various designs and the pictures of windows and other bits of architecture from famous buildings in many countries are of interest and value to all students of geometry.

There are over 1,800 exercises, and many of these are general problems from which any number of numerical problems may be formed. The drawings and illustrations number more than 450 and they are well drawn and printed on excellent paper. The extensive bibliography and index to problems and theorems will aid the teacher in selecting material. If the book can not be used in all high schools as a text it will prove of great usefulness as a reference book; and in courses in architecture and design its value as a text book can hardly be questioned. H. E. C.

Practical Geometry and Graphics, by David A. Low, Professor of Engineering, East London College, University of London. Pages vii + 448. 15 x 22 cm. Price, $2.50. 1912. Longmans, Green & Co., New York.

It was the purpose of the author to give in this book a fairly complete course of instruction in practical geometry for technical students. A glance through the volume is enough to assure one that it might well be called an encyclopædia. If at the present time it cannot be used as a text-book in this country, it ought to have a wide use as a handbook not only for technical students but also for engineers and draftsmen.

Especial care has been taken to provide illustrations which should be distinct and clearly show the constructions. There are in all 823 numbered drawings, and these figures take the place of many pages of directions for making graphical solutions and the like, and discussions. The exercises and problems which number about 700 add greatly to the value of the volume as a text-book.

The drawing of curves from their geometrical definitions or equations, approximate solution to some unsolved problems, vector geometry and graphic statics, plane co-ordinate geometry, periodic motion, and the various problems of descriptive geometry, is a brief outline of the contents of the book. Teachers of high-school mathematics will find this work a valuable reference book, and it ought to be in every high-school library. H. E. C.

A Manual of Laboratory Exercises in Physics, by Frederick R. Gorton, Michigan State Normal College, Ypsilanti. Pages, xv + 166. 13 x 20 cm. Cloth. 1912. D. Appleton & Company, New York.

A splendid book which was written, primarily, to accompany the author's "High School Course in Physics," although it can be used with any good text in secondary physics. There are fifty-two exercises, many of which are presented in two or more ways. There are more exercises presented than can be performed in an ordinary course of one year. This gives the instructor considerable latitude in the selection of the particular exercises for his course. The same general order is given for each exercise which is: name, object, materials, description and lastly, a set of review questions.

The descriptions are written in a clear and understandable way, so that the pupil will have little difficulty in his work. A price list of the apparatus used in the book is appended. There are, too, a number of tables of constants used in the exercises. These are also fine zinc etchings of a protractor, vernier scale and English metric scale printed on a good quality of cardboard. These are to be cut out and used by the pupil as occasion requires. There are fifty-five drawings and figures. The book is well made and is intended for use. C. H. S.

Complete School Algebra, by Herbert E. Hawkes, W. A. Luby, and F. C. Touton. Pages xi+507. 13x19 cm. Price, $1.25. 1912. Ginn & Co., Boston.

This volume includes the material of the authors' "First Course in Algebra" and "Second Course in Algebra" which have been reviewed in this journal. The first 280 pages cover the work usually given in the first year of high school, and the remaining pages include reviews and a broader treatment of the work of the first year with the advanced topics usually studied in the best secondary schools.

These books are well adapted to the purposes of most high-school teachers, and their wide adoption and continued use show that teachers find them satisfactory. Authors and publishers should compare the nine full-page portraits of mathematicians with the crude portraits that adorn (?) the pages of some recent high-school text-books. H. E. C.

Foundation and Technic of Arithmetic, by George Bruce Halsted, Ph. D. Pages, iv + 133. 15 x 21 cm. Price, $1.50. 1912. Open Court Publishing Company, Chicago.

The present volume is a welcome addition to the body of writings having to do with the history and the methods of teaching arithmetic. To teach any branch of mathematics with a high degree of efficiency the instructor must be conversant with its origin, foundation, meaning, aim, and its relation with other subjects and with the interests of the students. "In arithmetic," says Dr. Halsted, "a child may taste the joy of genius, the joy of creative activity." The child may have this opportunity under the vital instruction of a teacher well versed in the fundamental concepts and underlying principles of arithmetic as set forth in this volume.

The following are some of the topics considered: the prehuman contributions to arithmetic, the genesis of number, counting and numerals, the genesis of our number notation, addition, subtraction, multiplication, division, technic, decimals, fractions, relation of decimals to fractions, measurement, mensuration, order, ordinal number, the psychology of reading a number, arithmetic as formal calculus, and on the presentation of arithmetic. H. E. C.

Non-Euclidean Geometry, by Roberto Bonola. Translated with additions by H. S. Carslaw. Pages, xii + 267. 14 x 18 cm. Price, $2.00. 1912. Open Court Publishing Company, Chicago.

This work is an elementary historical and critical study of the development of non-Euclidean geometry, and requires for reading only a knowledge of elementary mathematics except in the last chapter.

Chapter I gives an interesting account of some of the attempts to prove Euclid's parallel postulate, from the time of the Greek geometers to the seventeenth century. In chapter II a brief discussion of the work of the forerunners of non-Euclidean geometry is given. Saccheri's work is given in sufficient detail so that one can understand it. Chapters III and IV give an exposition of the work of the founders of the subject,—Gauss, Schweikart, Taurinus, Lobachevski, and Bolyai. In chapter V the author describes the further development of the subject due to the work of Riemann, Helmholtz, and Cayley.

From the second to the nineteenth century attempts have been made in many countries to prove Euclid's parallel postulate and thus place it among the theorems. It was not till the nineteenth century that the impossibility of proving the postulate was conceded, and a self-consistent geometry based on the contradictory of this postulate constructed. The salient and distinctive features of Lobachevski's geometry, first published in 1829, are that through a given point an indefinite number of straight lines can be drawn in a plane, none of which cut a given line in the plane, and that the sum of the angles of a triangle is variable though always less than two right angles.

A careful reading and study of this volume by Bonola will give a teacher a new outlook on the field of geometry. H. E. C.

Elementary Book on the Calculus, by Virgil Snyder and John I. Hutchinson, Cornell University. Pages, 384. 14 x 19 cm. Price, $2.00. 1912. American Book Company, New York.

The authors' point of view is shown by the following paragraph from the preface. "The characteristic features of the books on the Calculus previously published in this series have been retained. The extensive use of these books by others, and a searching yearly test in our own classroom experience convince us that any far-reaching change could not be undertaken without endangering the merits of the book. The changes that have been made are either in the nature of a slight rearrangement, or of new illustrative material, particularly in the applications."

The book is not a treatise on mechanics. It gives a limited number of applications in mechanics, physics, and so on, but for the most part emphasizes the theoretical side of the subject and includes a large number of the old type of problems for drill in applying principles and in manipulation. H. E. C.

The A B C of the Differential Calculus, by William Dyson Wansbrough. Third Edition. Pages, xii + 148. 13 x 19 cm. Price, $1.50. 1912. D. Van Nostrand Company, New York.

If this book were in the hands of every student when he begins calculus the chances are that he would really understand the fundamental principles, and would pursue the subject with a larger measure of enjoyment because of the fact that he is not going blindly in a mysterious maze. The explanations really explain the meaning of a variable, differential coefficient, limit, differentiation, and so on, in simple and familiar language; and the illustrative examples which are drawn from every-day life serve to make clear the author's meaning. There are no lists of problems for solution, but the number of solved problems is quite large. H. E. C.

SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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